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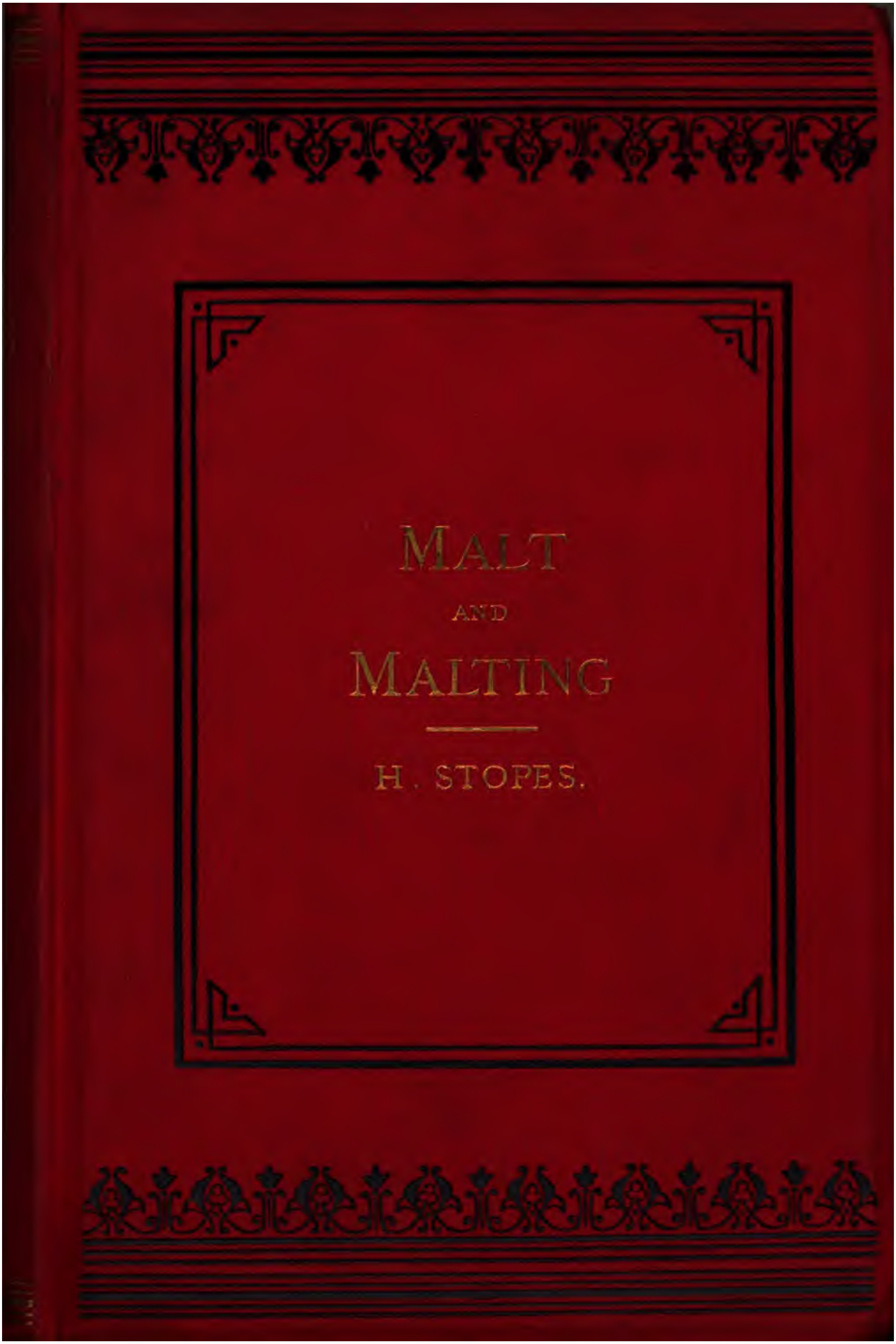

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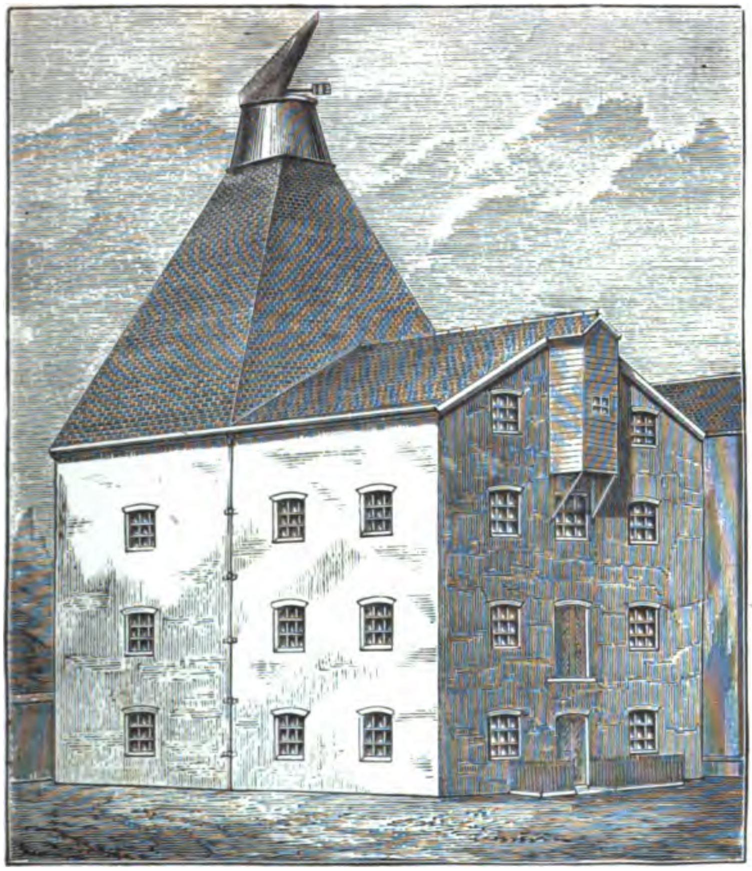

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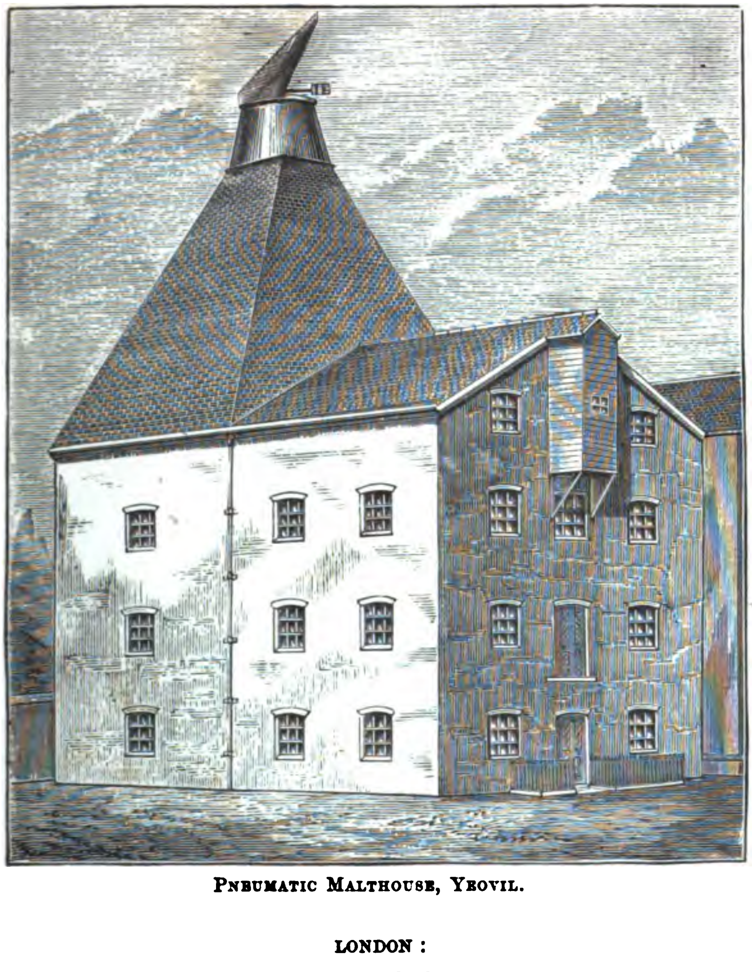

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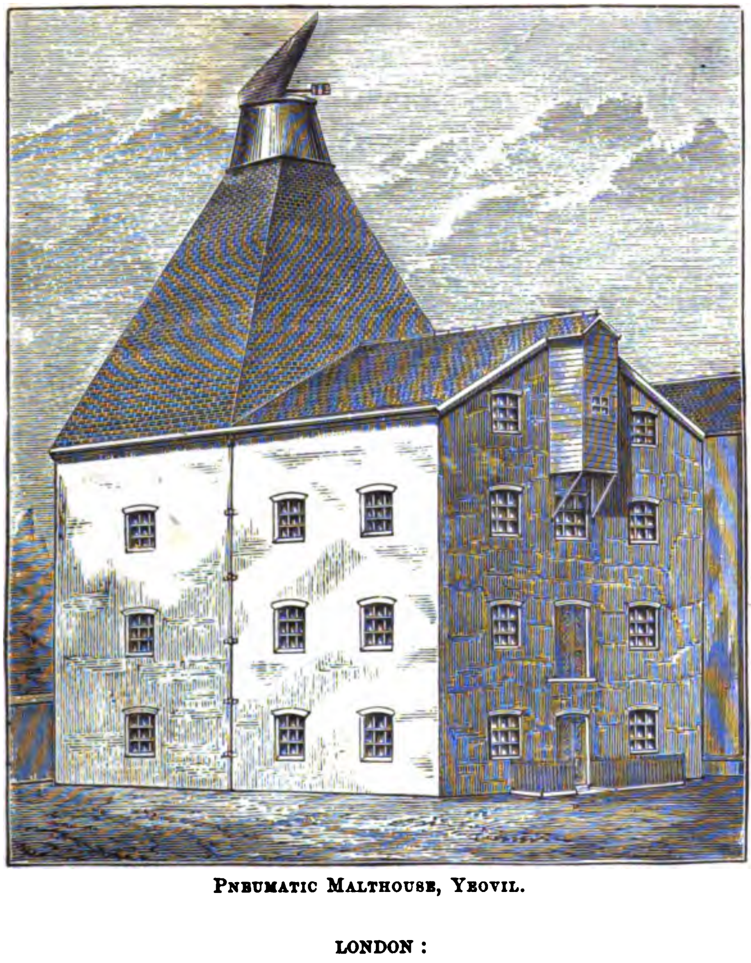

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TO

PICKERING PHIPPS, ESQ., M.P.,

NORTHAMPTON,

THIS WORK IS DEDICATED, IN TOKEN OF THE AUTHOR'S HIGH ESTEEM, AND WITH THE ARDENT WISH THAT SOME OF THE RISING GENERATION OF PRACTICAL BREWERS AND MALTSTERS MAY, IN THE FUTURE, BE AS DISTINGUISHED AND USEFUL CITIZENS AS THE HONOURABLE MEMBER FOR NORTHAMPTONSHIRE,

BY HIS OBLIGED AND SINCERE FRIEND,

H. STOPES.

PREFACE.

A SENSE of the importance of making malt rightly, in accordance with the best known principles and practices, has filled me with the desire to facilitate the ready attainment of all available knowledge of the subject, and has induced me to undertake the work of compiling this book.

That it has necessarily been a task requiring much patience and labour, is obvious. Now that it is accomplished I am keenly alive to many defects visible even to myself, and I anticipate some of the objections that can be urged to my treatment of the subject.

To practical men the lengthened history, preliminary treatment of materials, and profuse account of chemical composition, may seem tedious, or even useless.

To scientific men the poverty of treatment may occasion regret.

I would it were otherwise.

From those who may criticise me harshly, I shall probably learn somewhat more of my weakness or my ignorance.

To those friends who generously and kindly offer me encouragement, I can only say how gratefully I receive any indication that what I do or write is of any practical value to others.

I cannot conclude without thanking all those who have patiently assisted me, and especially are my thanks due, and freely given to Prof. GRAHAM, and also to my friend Mr. W. H. DALTON, F.G.S., for his untiring efforts to render this work complete, more particularly Chapters IX. and XI., the Bibliography, &c.

Freely and fully I have offered to friend and foe alike the matured outcome of my present knowledge and experience.

I have done my best to advance accurate knowledge of the whole of this great and important industry. Men of longer experience in the ways of the world may think I act indiscreetly, or at least in opposition to my own interest, in writing so freely as in many of the following pages. For that I care but little. I shall be sufficiently rewarded if the minds of the rising generation of men interested in malt are influenced by this work to become more enlightened and intelligent than their predecessors, so that the work they find to do shall be done better and more truly, and the material they manipulate shall be less spoiled and damaged than it is by us of the present day.

H. STOPES.

24A, *Southwark Street,*
London, S.E.

June, 1885.

MALT AND MALTING.

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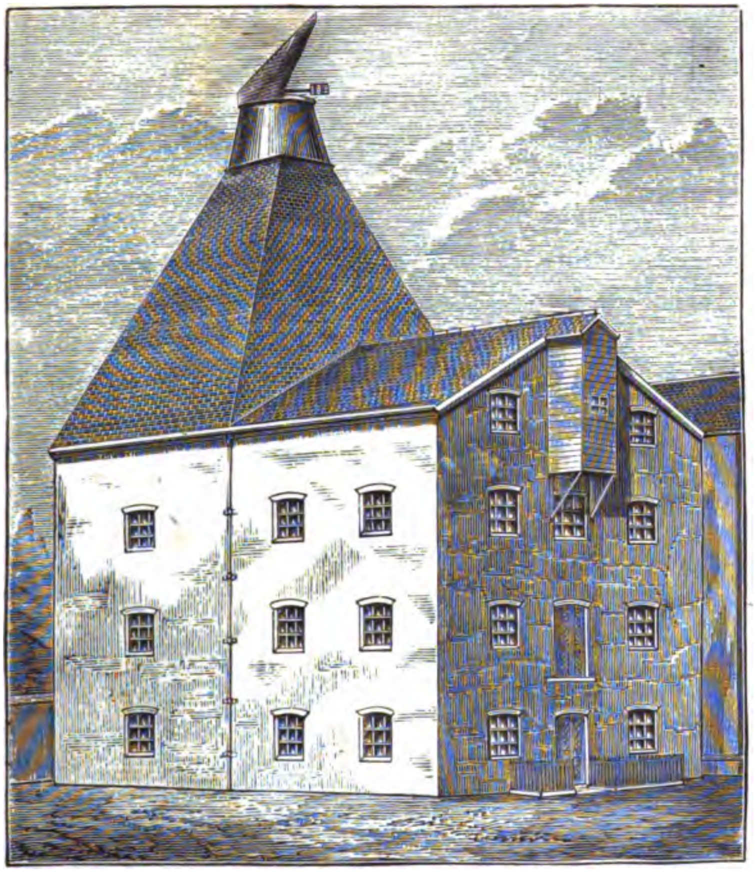

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others we have vague conceptions, whilst, doubtless, many more remain for future discovery. Each year brings within our reach more exact data from which to reason, as the processes are now being watched with more scientific precision, and it is well known that the physical sciences generally have advanced in exact proportion to the application of exact methods and statistics to the processes of inquiry. "How much?" and "In what proportion?" are vital questions. On the accuracy with which they are answered depends the solution of many problems of commercial importance, several of which must be solved in malting operations.

As the processes must be adapted to the nature of the raw material, and as the structure of the buildings necessarily affects the mode of working, a book on the subject of malting would be incomplete without reference to the form of the buildings and tools needed for carrying out the process. If these are defective the resulting product suffers, and much imperfect malt is the consequence of badly-planned maltings, in which scientific working is impossible, even with the best of grain.

English maltsters, being now free from the unscientific restrictions of the Excise Laws, can avail themselves of a variety of improvements, both in processes and buildings, the best of which, at present discovered, will be described in the following pages.

CHAPTER II.

HISTORY OF MALT LIQUORS UP TO 1300 A.D.

An exhaustive treatise on the sole topic of malt necessarily includes as complete a retrospect into the early history of the manufacture as is permitted by the fragmentary nature of the records of social life in the past.

Few people, except those who have thought out the subject, are aware of the curious influences exerted upon national character by the possession of intoxicating or stimulating beverages, or rather by the nature of the alcoholic concoctions in ordinary use; for some form or other of alcohol is used by nearly every nation now existing upon this earth, and apparently few people of any age or clime have ever existed who have not made use of alcohol in one or more forms.

Apart from the historical interest it may excite, it is a matter of very slight practical importance to trace the history of malting. Probably it will be found that some such process was known to most of the earliest races of men of whom distinct records remain.

As in most manufactures, a fairly good system of working was evolved by the steady observation of cause and effect, long before any one of the laws affecting the matter was ascertained or even thought of.

As illustrations of our subsequent advance, both in knowledge and mental grasp, some of the following quotations are interesting. The rarity of the works whence they are taken sufficiently excuses their length, while the quaintness of style and absurdity of idea have at least this value: they remind us that the most advanced scientific and practical writing of to-day may, in time, seem as strange and erroneous to our successors as these seem to us. Those whose happy fortune it shall be to live in later times will derive the benefit of the combined experiences.

The earliest traces of the cultivation of barley that have hitherto been found, occur in the relics of grain stores in the Swiss lake dwellings. Professor Heer* figures the ears of the two varieties of *Hordeum hexastichon, var. densum* and

---

* Die Pflanzen der Pfahlbauten (The Plants of the Pile-buildings). 4to. Zurich, 1865.

var. sanctum with those of other grain in his description of the discoveries. He makes no mention of malt being found, but though there is little or no direct evidence, there are pretty strong indirect suggestions that the properties of beer were known, as well as the benefit of the use of malt in its preparation. We have at least sure proof that it was known in very early times in Egypt, and we find in the classical writers of antiquity copious allusions to the preparation, use, and effects of fermented liquors made from barley, wheat, &c., by the ancient races of Europe, Asia, and Africa. I will not burden the present work with quotations from these authors, but summarise their statements briefly, in order to show the antiquity of the manufacture and its great extent.

From the circumstance of no mention being made of beer in the books of Moses, it has been rather rashly concluded that such a drink was unknown in his times and in his vicinity. This, however, is not the case. The vine was cultivated in Egypt only in those districts which were beyond the reach of the inundations, and the quantity of wine raised being limited, was reserved for the rich, while the poorer classes had to content themselves with a cheaper drink prepared from barley. Some of the figures in the Boulak museum seem to be engaged in malt making.

The remains of malt were found at Thebes by Sir J. G. Wilkinson.*

Dr. S. Birch (editor of Wilkinson's work) adds (p. 396, note) "The ancient beer called (*heqa*) is as old as the 4th Dynasty; it was made from red barley or malt, bet tes'er. The foreign beer came from Kati, a country to the east of Egypt, celebrated for its production, and there were two kinds, alcoholic and mild, employed in medicine (Chabas, Mélanges, t. i., p. 15). The Egyptians indulged in beer, and the description of a person overcome by intoxication is given in papyri of the time of Seti I. [1300 B.C.] (Goodwin's Cambridge Essays, 1868, p. 253). That it was superior to the beer made in other countries may be readily inferred from the eulogiums passed upon it by the historian, contrasted with the contempt in which this beverage was held by the Greeks. See Æschylus in the 'Suppliants,' verse 960."

Herodotus (450 B.C.) is perhaps the earliest profane writer who gives any particulars regarding Egypt, and he describes beer prepared from barley as the ordinary drink of the Egyptians in his day.†

In common with other writers of antiquity, he ascribes the art of brewing to Isis, wife of Osiris, better known as Rameses II., 1960 B.C., and it seems tolerably certain that if Rameses did not invent, he promoted the manufacture of alcoholic decoctions of barley to a very considerable extent.

Pliny, Aristotle, Strabo, and others, who mention this beer by the name of *Zythos*, give full descriptions of its qualities and intoxicating properties; and Diodorus* affirms that some kinds were so palatable as to be scarcely inferior to wine.

---

* The Ancient Egyptians. † Herodotus, book ii., cap. 77.

Other references to malt liquor, under the names *sythos*, *bruton* (brewage), *oinon krithinon* (barley wine), and other names are found in the following authors.

Æschylus, Fragm., 116; Suppl. 954, 960.
Archilochus, xxvi. 6; xxviii.
Aristotle.
Athenæus, i. 28, 34; x. 67, 418, 447.
Columella, x. 116.
Cratinus Malth., iv.
Diodorus Siculus, I. xxvi., 350; IV., ii.; V., xxvi.
Dioscorides.
Geoponius, VII. xxxiv., 203.
Hecatæus, Fragm., 123.
Hellanicus, 110.
Isidorus, Origines, XX., iii., 17.
Orosius, iv., 259.
Plautus.
Pliny, "Naturæ Historia," xiv., 29; xxii., 82, 88.
Sophocles, "Triptolemos."
Strabo, xvii., ii., 5.
Tacitus, "Germania," xxiii.
Theophrastus, "De Causis Plantarum," vi., ii.
Ulpian, "Dignitates," 33, vi., 9.
Virgil, "Georgics," iii., 380.
Xenophon, "Anabasis," IV., v., 26.

In some of these allusions it is not clear whether true malt-liquor is meant, or a fermented decoction of meal or bread. Tacitus speaks of "barley- or wheat-water corrupted into some semblance to wine." Pliny says, "liquor made from steeped corn." Probably, in some cases, the grain was left steeping till fermentation set in, and the steep-water became part of the "cold mash."

The practice of distilling and of drinking ardent spirits existed in India in very ancient times. In the old Sanscrit law books we read of mead, a spirit distilled from honey, arrack from palm-juice, rum from molasses, a spirit distilled from rice, a spirit from flowers, and many other sorts. Instit. of Menu, ix. 235; xi. 91, 95, 96, &c. See also Ramâyana, i. § 41, &c.; and the Sâma Veda, Sanhitâ, *passim*.†

But among the ancient Britons, at any rate, true malt was made and brewed. An account of the process, translated from Geoponius (*loc. cit*), is given in Henry's History of England (vol. ii. p. 364). "The grain was steeped and germinated, by which its spirits were excited and set free; it was then dried, and ground and infused in water, when, after fermentation, it produced a pleasant, warming, strengthening, and intoxicating liquor." The lapse of time has involved vast changes in these several processes, in the raw material, and in the finished product; but the sequence of the operations and the general tendency of the resulting beverage remain the same. The Romans much promoted the industry in Britain, and we find reference to malt liquor in the laws of Ina, king of Wessex.

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* Diodorus, lib. i., cap. 20, p. 34.

† P. H. Gosse, Assyria: Her Manners and Customs, Arts and Arms (1852) p. 510.

The Danes were great drinkers of beer, so much so that Edgar, acting by the counsel of Dunstan, in A.D. 970, put down many alehouses. Villages were allowed one alehouse only, and but very few were permitted even in great boroughs. One device for diminishing drinking was legalised at this time which is very curious. Cups were made with pegs or pins inserted at regular intervals. Whoever drank below the mark at one draught rendered himself liable to a fine.*

Miss E. J. Oswald, (authoress of "By Fell and Fjord,") tells me that in the Icelandic Sagas beer is frequently referred to, and although the accounts of its manufacture are rather obscure, it is easy to gather that it was drunk very new, a feast being always preceded by a brewing as well as a baking, whilst an unsuccessful brew was a terrible misfortune, the king and his court sitting sulkily over their ale, all in a bad humour at the failure of this essential adjunct to their merriment.

The Norse legends and the German literature of all ages contain copious allusions to the manufacture of beer. Indeed, the Teutonic races have worshipped Gambrinus with steady devotion for unreckoned generations, and a formidable volume could be filled with quotations illustrative of this venerable cult.

Ale is mentioned in connection with a banquet of which Edward the Confessor partook. It was then known in Scotland and Wales, and estimated thus:—1 cask mead = 2 casks spiced ale = 4 casks ordinary ale. The value of spiced ale was the equivalent of £7 10s. for a cask 9 palms long by 18 palms diameter [? circumference].†

Hume (Hist. Engl., vol. ii. p. 224) refers to a statute of Henry III., 1272, allowing brewers to sell two gallons of ale in a city for 1d., and three or four gallons in the country for the same price, the effect of strong liquor on persons engaged in sedentary occupations being recognised thus early. One of the early passages referring to beer by that name is in an Act of James III. of Scotland, A.D. 1482.

The monastic system was favourable to the development of malting and brewing. The monks, for several centuries, were famed for the excellence of the malt they made and the ales they brewed. In common with many other arts and manufactures, malting derived benefit from the care bestowed upon it by the reverend fathers, who loved their nut-brown ale, and

[*] HOLINSHED'S Chronicle, circ. 1580 A.D.

[†] REES' Cyclopedia, 1816.

who studied with painstaking care the relations of cause and effect.

William of Malmesbury asserts that as far back as the time of Henry II. of England many monasteries were famed far and wide for the purity and strength of their ales brewed from malt made with much skill and care. A document still existing refers to a re-leasing of some lands at Burton-on-Trent to the abbot of the religious house at that place, by Matilda, daughter of Nicholas de Shoben, in 1295, upon condition of a daily toll of bread, beer, &c.

The monks of Wetmore discovered the brewing qualities of the Burton water in the thirteenth century.

CHAPTER III.

HISTORY OF MALT SINCE 1300 A.D.

We have now reached a date within six centuries of this year of grace, and as England has ever since taken the lead more or less in matters relating to malting, our attention will now be more strictly confined to our own country. Unhappily, the development of the trade is most fully elucidated by following the absurd legal enactments that have perpetually bound and fettered it.

Brief allusions to many laws, and rather copious extracts from the writings of the few authors upon the subject, will furnish the student with an outline of the past of malting, and may repay the attention of practical maltsters.

In the ninth year of Edward II. (1315) Stow states*—"The Londoners, considering that wheate made into malte was much consumed, ordayned that from henceforth it should be made of other graine, and also that a gallon of better ale should be solde for three halfpence and of small ale for a pennie, and not above. So the King, according to a statute of London, sent his writtes through the realme, commanding that as well within ye liberties as without, a gallon of ale should be solde for a pennie, and from henceforth no wheate should be made into malte, which, if he had not the sooner caused to be proclaimed, the greatest part of the people should have perished through famine."

During this same year (1315) an Act was passed permitting malt to be sold in heaps. Although maltsters were not compelled to pay the heavy duties in those days which their descendants groaned under, the law interfered with the ordinary course of their business to a painful and irksome extent.

By an Act passed 17 Richard II. c. 4 (1394), restrictions were placed on the sale of malt from Huntingdon, Hertford, Bedford, and Cantabridge to London, unless duly cleaned from all dust and combs. Strangely enough, this law was repealed 19 and 20 Victoria c. 64. Then, in the 33 Henry VI. c. 4 (1455), order was made that no person brewing ale or beer in Kent to be sold shall during five years make above a hundred quarters to his own use. At this early period other laws existed concerning taxes, and the restrictions placed upon maltsters, that were made and repealed, leaving little trace behind them; but in the 2 and 3 Edward VI. (1548) an Act was passed which, although several times repealed, was re-enacted, not being finally cleared from the Statute Book till 26 and 27 Victoria c. 125. It was entitled, "A True Bill for the Making of Malt," and exerted an immense deal of influence over the trade for a hundred and fifty years. It set forth "That where divers and sundry persons taking upon them the art and mystery of malt-making, and sundry other persons, tendering more their own private lucre, gain, and profit than the wholesome victualling of the King's Majesty, the nobility, and other his Grace's subjects, have of late, by their unsatiable, covetous, and greedy minds, accustomably and commonly made such malt impure and unseasonable, for that they have made the same in eight or nine days, when indeed the same cannot be well and perfectly made unless it have the space of 21 days in the making thereof. . . . . And for that they would have an inordinate increase . . . . Not being sufficiently dried, it cannot be kept, but will be musty and full of weavels, whereby no wholesome drink for man's body can by any means be made thereof, to the great peril of the King's subjects," and so on, showing that fifty quarters of malt were needed where forty should do if well made, and also how "all this was contrary to honest, seemly, and good buying, selling, and commutation that should or ought to be amongst Christian people, especially in things concerning the sustentation of man's body." It was then enacted that after the 1st March next (1549) no one should make any barley malt, the months of June, July, and August excepted, but that should have in the fat, floor, steeping, and drying twenty-one days at least, and during the excepted months seventeen days. Then if the malt for sale were not so trodden, rubbed, and fanned that a quarter yielded half a peck of dust, the maltster was fined twenty pence for every quarter. This law, having lapsed, was renewed by Elizabeth in 1585, and again enforced in the thirty-fifth and thirty-ninth years of her reign. 21 James I. c. 28, and 3 Charles I. c. 4, was repealed by a separate Act in 1698, as it was found to act against the proper collection and profitable yield of the new malt duty imposed in 1697, and was not finally cleared from the Statute Book till so lately as 26 and 27 Victoria.

---

* Stow. History of England.

In 1585 a very curious and valuable book of fifty pages was published by a Bohemian, Thaddeus Hagesius, at Hagen, called "De Cerevisiâ ejusque conficiendi ratione, naturâ, viribus, et facultatibus." It describes the processes of brewing accurately and simply. It has not the merit of being the first treatise upon the subject, as an earlier one was written by Basil Valentine, and in 1573, Knaust issued an elaborate work upon "The Divine, Noble Gift, the Philosophical, Highly Dear, and wondrous Art to Brew Beer." At this time (1585) the trade of London amounted to 648,690 barrels of beer per annum brewed in twenty-six breweries.

As early as July, 1634, we find a patent taken out by one Nicholas Page for "making a kyll for drying malt and hops with sea-cole, turf, or anie fewel, without touching smoke," &c.* This was followed in twelve months by a very similar patent taken by Sir Nicholas Halse, and two years later (1637) a noble inventor—Thomas, Earl of Berks—patented another kiln for drying malt, hops, &c.

1644. The malt duty was originated, which gradually grew into the charge so well known to all of us, and which lasted, with numberless alterations, for 236 years. It first came into force when money was urgently needed to carry on the fierce struggle of the Civil Wars, that threw the country into such wild confusion, until poor Charles I. lost his head at Whitehall. All malt made from wheat or barley paid a duty of 2s. per quarter, and from oats, of 1s. 4d. per quarter. This was in addition to a heavy tax upon beer, amounting to 12½ per cent. of its value by private brewers, and 25 per cent. by inn-keepers and brewers for sale. This establishes a very early precedent for the taxation of private brewing.

1662. In the 2 Charles II. an import duty was placed on malt of 3s. 4d. a bushel, if it were of a value less than 3s. 6d. per bushel, and of 5s. if it exceeded that value. If exported, a general charge of 10s. was made.

William and Mary gained an immediate advance of £1,000,000 by means of a lottery, offering as security for the money so gained the salt-, beer-, and malt-duties that then existed.

1688. By 2 William III. c. 24, to meet the heavy charges of the war with France, another addition was made to the tax on beer. In the same Session an Act had been passed giving a bounty of 2s. 6d. a quarter upon every quarter of corn and malt that a master of a ship carried to any foreign port. This Act was confirmed by c. 24; and for many following years, when corn was cheap and plentiful, it came into force, being occasionally repealed for exceptionally dear and scarce years.

In 1691 Tryon wrote the third edition of his curious book, "The New Art of Brewing Beer, Ale, and other sorts of Liquors," which is quoted more fully further on.

The year 1697 has been for generations a memorable one in maltster's annals, as the celebrated Malt Tax was then first imposed upon its final basis.

In a work of this kind it is unnecessary to enter at any length into the numerous changes of law that have constantly taken place for nearly two centuries. A brief summary must suffice, but all the more important Acts of Parliament bearing upon the subject are alluded to in such a form that they can be readily referred to. In 9 William III. c. 22, we find the duty placed in a form that continued without any real alteration, excepting as to amount of charge, until September 30, 1880, although it suffered many changes, and became the best-abused Act that has been passed since the restoration of Charles II. The war with France led to its imposition. At first, and for many years, it was only a moderate charge of 6d. a bushel, but subsequent wars led to gradually-increasing rates, until in 1801 it rose to 4s. 5¾d. per bushel, and continued at that ruinous rate until after our war with France ended (1816). In 1702 (1 Anne c. 13) money to such an extent had been borrowed, that, over and above a duty paid by malt, a deficiency still existed of £579,060 upon the so-called malt-tickets, which led, in 1709, and after years, to more lotteries upon the security of the malt-duties. Up to 1713 malt-duty had only been collected in England and Wales, but in this year an Act was passed extending it to Scotland (12 Anne, st. 1, c. 2), making the duty 6d. a bushel—the same in both countries. An attempt had been made by the Scotch Parliament in 1695 to establish the duty, but it met with such decided opposition that it was deemed wiser to abandon it. Great efforts were made to prevent its establishment by the Imperial Parliament—so great, indeed, that they very seriously threatened the Union. In fact, the Scottish peers tried every means within their power, not even stopping at personal remonstrance with the Crown; and the Earl of Findlater moved, in the House of Commons, for leave to bring in a bill to dissolve the Union in consequence. Despite all opposition, the tax was imposed, and, as a consequence, intense dissatisfaction spread through the country, and continued for many years. Maltsters everywhere refused to be surveyed, and no proceedings at law by the Excise were of the slightest avail, as in no county of Scotland would the justices act. This state of affairs continued until 1725, during which year the duty north of the border yielded exactly £11 2s. The Government now determined to enforce payment, and sent two companies of soldiers to Glasgow to assist the officers of the Excise in their work, and to protect them. But so great a riot followed that the military were completely intimidated by the mob, who, flushed with their victory, repaired to the house of Mr. D. Campbell, then member for Glasgow, and completely sacked and ruined it. Next day the rioters drove the soldiers to Dumbarton Castle, with the loss of six men, and all their baggage. So great was the hatred to this tax, that the whole country was prepared to do the same thing, and it was not accepted, nor order restored, until an arrangement was made that all the money raised by it in excess of £20,000, should be devoted to the encouragement of Scotch manufactures and industries, particularly the ports and fisheries. For a whole century the duty was kept considerably less in Scotland than in England and Wales. At the first charge it was only 3d. a bushel.

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* Fuller notice and descriptions of more remarkable and useful patents will be given in the later pages of this book.

Returning to 1713, this year the first allowance was made of duty upon all malt lost at sea, or destroyed in a few other ways, and a number of provisions, that have continued up to this date, were instituted as to the working of barley, and allowances established for swell in cistern and on floors.

In this year also, by the Act 12 Anne, private families were permitted to compound the malt-duty at 5s. per head, and so generally was this privilege accepted that nearly two-thirds of the malt made paid duty in this form.

In 1714 (1 George I. c. 2) the duties were confirmed, but maltsters were allowed four months' grace for payment after entry. This led to many men of straw becoming maltsters, who had time to make and sell their malt and decamp before paying the collector. Up to this time, too, great quantities of malt had the drawback allowed upon which the duty had never been paid, and also large quantities had grain mixed with it, upon which duty was claimed. To stop this, a fine of 5s. a bushel was charged upon all malt so treated, if detected. But the evil grew, and had to be more stringently dealt with in 1719. Complaint was made that not only was the barley not properly placed in the "uting vat," but was allowed to "acrespire" to such an extent as to greatly prejudice the malt so made, and British credit also, and to secure to the maltsters more drawback, to the loss of the revenue. Such very stringent laws were made as to steeping, growing, &c., that maltsters have ever since had to pay for the greed of their predecessors of 160 years ago. A great number of Acts had to be passed about this question, such as, in 1725, the malt was to be carried directly from the kiln to the ship, in the presence of the officers, after twenty-four hours' notice, nor could any maltster commence to make for export until six days after the floors were clean swept, and when he had finished he must wait six days more before commencing for home use, with many more equally stringent regulations, to the extent that if malt made for exportation were not sent away within nine months of making, the maltster had to forfeit 5s. the bushel; and in 1742, every maltster was ordered to clear out old stocks entirely and start afresh.

In 1722 provision was made to enable the drawback to be claimed upon other damage, not yet noticed, to malt, that spoilt it for use throughout the kingdom.

1724. The Act was extended more stringently to Scotland, which led to the disturbances previously mentioned. Strangely enough, it was coupled with a tax upon newspapers and pamphlets.

1728. Another Act was passed, still more stringently preventing maltsters mixing different growths together, and other little dodges resorted to in order to escape payment of duty. During all this time it was only a charge of 6d. a bushel, and continued at that low rate until 1760. The Act authorising the collection of duty, although made perpetual, was renewed year by year for many years.

1760. By 33 George II. c. 7, the duty was now raised to 9d. in England and Wales, and 4½d. in Scotland, and was directed to be paid upon all malt, whether for sale or for private use. All stocks of malt on hand to pay the increased rate on the following February 8th. This increase of duty was to secure the sum of £8,000,000 upon the new duty, which was raised as a lottery, every subscriber of £100 being entitled to one lottery ticket.

1762. Notice of wetting was now enforced for the first time, but it underwent a variety of changes.

1779. Another increase of duty to the extent of 15 per cent., which was directed to be paid every week, and kept entirely distinct from duties already imposed; and the following year a further rise of 6d. in England and 3d. in Scotland took place. All stocks on hand on May 30th to pay the increase. To encourage common brewers, and those who sold and tapped out ale, from the moneys so raised, brewers for sale received back upon every barrel of ale of a value of 6s., 1s. 4d. in London, 1s. 8d. everywhere else in England and Wales. If of less value than 6s. the barrel, then 4d. only per barrel was allowed. This drawback was paid to brewers every four months. By the same Act, an additional 5 per cent. upon all previous duties was charged.

1790. By 31 George III. c. 2, the confusion of duties reached its climax. An addition of 3d. per bushel in England and 1½d. in Scotland was made to all existing charges of the duties so raised. Common brewers got back 8d. per barrel on strong ale in London, and 10d. per barrel elsewhere, with no less than eight variations as to drawback for different varieties of ales and in different places. It was not a happy thing to be an exciseman in those days, and Dr. Johnson's definition of the term excise was quite capable of a double meaning, when, in his dictionary, he wrote thus: "excise, n.s., accijis, Dutch; excisum, Latin; a hateful tax levied upon commodities, and adjudged not by the common judges of property, but wretches hired by those to whom the excise is paid." Gentlemen of the excise had nearly as much cause for unhappiness as brewers themselves in these "good old times."

1800. An Act was passed, which was renewed a number of times as occasion required. To meet the necessities of a singularly wet season, by 41 George III. c. 6, maltsters were allowed to steep for the short time of 20 hours, if they desired, instead of 40 as hitherto, so as to allow for the excess of moisture of the corn. This Act kept in force till July 5th, 1801.

1801. Additional power was given to officers to measure the corn in couch, to determine if any attempt had been made to press. This vexed question was the source of much fruitless legislation, until the happy phrase was hit upon that a certain standard in excess of normal swell should be accepted as "conclusive evidence." Maltsters never overcame that. On the union with Ireland the duty in that country was slightly larger than in the other parts of the kingdom.

1802. The duties were again raised by 42 George III. c. 38, 1s. 0½d. per barrel in both England and Scotland, and the existing excessive tax upon beer was raised another 2s. per barrel upon every description of beer alike, both strong and table-hops also being heavily taxed, and the former allowances upon beer were discontinued. This was a very long Act, filled with every kind of restriction, and bristling with pains and penalties relating to almost every process of the making of malt and beer, together with the sale, exportation, and consumption of all articles in the trade, a noticeable feature of the Act being that sprinkling at the maltster's discretion was for the first time restricted, not, however, without provoking the utmost opposition of maltsters and others. Malt at this time paid duty to the extent of 2s. 5d. per bushel only; but it must be remembered that beer, hops, &c., were all heavily taxed.

1803. By 43 George III. c. 81, a further increase of 2s. per bushel was made to the duty then charged, so that at this time, and for the twelve following years, the duties paid by common brewers were, license from 20s., every barrel of ale of a value of 16s. per barrel, tax 10s.; every barrel of table-beer value of 6s. per barrel, tax 2s.; maltster's starting license 5s.; every bushel of malt made 4s. 5d.; hops taxed at 23s. 4d. per cwt. Slight reductions were made in Scotland, and still larger ones in Ireland. These heavy duties were occasioned by the wars England was then waging for the benefit of her neighbours, and were continued for a dozen years with countless changes in form, but little alteration of amount, so that it is tedious in the extreme to wade through the Acts that were being perpetually passed, most of which only made confusion worse confounded.

1804. Bere or bigg was now charged with duty for the first time.

1808. Maltsters were ordered to keep barley-stock books open to officers' inspection, in which all barley received and used or wetted was to be accurately entered, under heavy penalties if any fraud were discovered. As may be readily imagined, these books received little favour; still, they were continued for a number of years, and produced a strong feeling of ill-will between officers and maltsters. As traders were treated as if honesty were an unknown virtue, they in turn seemed to think that they were at liberty to cheat whenever and wherever opportunity occurred.

1812 marked still more stringent regulations upon the shape, position, and use of cisterns, and also the number and arrangement of the floors were regulated by Act of Parliament. A brewer who made his own malt, was at that time, and for the next three or four years, not only one of the most heavily-taxed of any section of the community, but also one whose trade was more completely regulated by law than any other. No trade at this time escaped, however, either direct taxation or legislative interference.

1816. At last, Napoleon being finally settled, and the country beginning to reap the advantages of peace, on all malt held in stock on July 5th the sum of 2s. per bushel was allowed to be repaid to maltsters. It is edifying to find that at that time, as more recently, great complaints were raised at the insufficiency of the quantities measured in bulk, as compared with the actual bushels measured by hand, and the result of all such complaints was merely to provoke the retort "that no such outcry was raised when the same mode of ascertaining quantities was adopted when imposing the additional charges in 1802 and 1803." By this Act, 56 George III. c. 43, the duty returned to the same charge as at the beginning of the century, viz., 2s. 5d. per bushel in England, 1s. 8d. in Scotland, and 2s. 4½d. in Ireland. Nor was this all the relief afforded, for the same Act determined all the increased duties on beer. Still, as maltsters and others had grown to be people of exceeding wickedness in those days, a great many pages of pains and penalties for misdeeds had to pass the House, and stand on the statute-books of the realm.

1819. It was found necessary again to raise the duty to 3s. 8d. per bushel, and for the first time since the disturbances at Glasgow of a century before, was the duty made the same in Scotland as in England and Wales. But great consideration was shown in the collection of the increased duty upon all stocks of malt held in hand, payment being ordered, by 59 George III. c. 53, to be made in four instalments, two of 3d. and two of 4d. each, extending over from November to April of the following year, and, in addition, 5 per cent. increase was allowed, and by the same Act a brewer was allowed to increase the price of his table-beer.

1822. By 3 George IV. c. 18, the duty was again lowered 1s., to come into force February 25th, 1822.

The malt duty was singularly little affected by the coming into force, in 1825, of the standard measures, whereby the use of the imperial gallon was alone legal, although the Act caused all duties to be revised. By 6 George IV. c. 58, all former duties ceased, and, instead, a tax was placed upon beer of 9s. 10d. per barrel of 36 imperial gallons, if of a value of 16s. and upwards; if less, or table-beer, then the duty was 1s. 11¼d. per barrel only. The twopenny ale which figured in the treaty between England and Scotland was charged with duty at 4s. 1d. per barrel. These charges were reduced to 10d. and 2d. respectively to common brewers, not retailers. The duty on malt by this Act was charged at 33s. 4d. upon every 100 imperial gallons, which, being the same as before, no change took place.

1827. By 7 and 8 George IV. c. 52, An Act to consolidate and amend the law concerning the malt duty, a great number of regulations came into force as to the entry, shape, construction and use of cisterns, couch-frames, specimens, keeping of barley-books, malt-stocks, kilns, number of floors, and right succession of growths, together with every detail connected with the business; but no difference was made in the rate of duty, and 101 penalties in all were attached to infringements of the clauses of this Act, amounting to a total of £13,500 should an unfortunate trader be careless or wicked enough to break them all. These things again occasioned a long Act three years later, 12 George IV. and 1 William IV. c. 17, and by the same session, c. 51, the duties on beer ceased, excepting the hereditary duties, which were suspended only during the king's life, and were to revive at his death. In lieu of these duties the Excise bore a charge of £354,500 per annum. This Act originated the payment of duty on malt used in brewing, and fixed it at one barrel for every two bushels of malt used, a rough and ready calculation of average extract, which all the scientific development of brewing for a half century has been unable to improve. The drawback on exported beer was fixed at 5s. per barrel. By this Act, also, many of the restrictions that were placed on brewers came into force, which were swept away by the repeal of the Malt Tax by Mr. Gladstone.

1835. By 4 and 5 William IV. c. 51, maltsters, if overcharged, were empowered to complain to either two commissioners of Inland Revenue, or two justices of the peace, within twelve months of the overcharge. If they could prove their case then were they entitled to be repaid by warrant, authorising the amount to be deducted from the next payment falling due from them. Various provisions were made as to the mode of appeal, and other things, for, like everything connected with the trade, it took a vast amount of legislation to settle a simple question, the same points appearing in several later Acts, such as 4 Vic. c. 20, 28, and 29 Vic. c. 96, &c.

1837. The much-vexed question of the barley-books was set at rest by the Acts establishing them being repealed. This was done by 7 Will. IV. c. 49, and the same Act gave a little further addition to the restriction upon couch-frames, sprinkling floors, and other things.

1840. By 3 and 4 Vic. c. 17, the additional charge of 5 per cent. was made to the duty, that raised it to the same price which was continued to the repeal of the duty, which remained without further change excepting during the years of the Crimean War, when it was temporarily increased.

1842. The Roasted Maltsters' Act, 5 and 6 Vic. c. 30, was filled with provisions that affected very slightly general maltsters, but which tied very closely the action of roasters, by means of strict supervision and exceedingly heavy penalties. A modification of the old barley-books was instituted, together with the system of certificates, so that by means of a double check the opportunity for fraud was very greatly reduced. The hours of roasting were regulated, so that during the winter the working-day was fixed at 13 hours, and in summer 14 hours: any maltsters working at night, or out of the prescribed hours, being liable to ruinous fines. Some sections of the community were excluded from roasting malt, such as grocers, druggists, &c., unless they were already in the business prior to 1842.

1855. By 18 and 19 Vic. c, 94, no barley was allowed to be made into malt under seven days from the time of emptying cistern to the commencement of loading the kiln, and other grain in proportion. By this Act, distillers were allowed to make malt for distillation, duty free, under certain restrictions; the house was to be especially approved by the commissioners to be used for the one purpose only; sufficient bond to be found by the maltster; the officer to have the kiln under his special charge, he alone keeping the key of it, accommodation for the officer to be furnished at the maltster's expense; secure rooms also to be provided for the deposition of the malt on removal from the kiln, placed in such a way that the officer should see from the room into the kiln, and also another room in which to store the malt previously to grinding it, and a mill-room, all under special supervision, the officer keeping all the keys; the mills, in this case, however, to be stones if desired. The numerous restrictions in this case are wearisome to wade through.

1859. By 22 and 23 Vic. c. 18, the limit of credit was curtailed to twelve weeks, and then only to men who gave ample security by bond, and the following year this time was still further reduced to six weeks. This, again, two years later, was altered, so that, under certain conditions, credit was granted for three months upon malt made between 1st January and 1st April, such duty, however, having to pay interest at the rate of 3½ per cent., care being taken to enable the collector to enforce payment promptly if any doubt arose as to a maltster's credit.

1860. By 23 and 24 Vic. c. 13, more restrictions were made upon time of steep, notice of wetting, removal of grain from cistern, mode of placing in couch, together with minute directions as to two or more cisterns in one house, and all the rest of the things that five centuries of successive cobbling had not sufficed comfortably to settle. Sprinkling also occupied the serious attention of legislators, and it was decided that to sprinkle before the expiration of the twelfth day should be as illegal as they considered it immoral. Drowning the corn for fifty hours altered the case, so all such corn was allowed to be sprinkled at the fifth day, upon due notice having been given. Five years later this time was reduced to ninety hours, other differences being made by distillers. Another very knotty question was the adjustment of the drawback allowed on malt exported; here, again, the careful deliberations of this session were altered and re-altered *ad nauseam* later on.

Under the Act 23 and 24 Vic. c. 110, foreign malt was allowed to be imported upon payment of a Custom duty of 25s. per quarter. Prior to this time the importation of malt in any form had been strictly prohibited. Mr. Gladstone's reasons for assessing this duty at 25s. were given at length (August 7, 1860), and are rather curious. The mode of making up the amount is as follows:—

	s.	d.
Duty	21	8¼
Corn duty	1	0
Interest on duty for six months . . .	0	6
Excise restriction and licence . . .	1	9¾
	25	0

In the same year, by an Act 23 and 24 Vic. c. 113, a drawback on all malt exported was first permitted. These unwonted permits gave naturally a great scope for the invention of innumerable restrictions.

1863. Malting for cattle feeding received a fresh stimulus by allowing barley to be malted by farmers or maltsters, provided it was duly mixed with linseed-meal or cake, to prevent its possible use for beer. Maltings worked in this way were under similar restrictions to distilleries. In spite of the freedom given to farmers to germinate grain for feeding purposes, very little practical use was made of such liberty, and although just at first a number of houses were started, duly painted, and labelled, "Entered to make malt, to be used in feeding animals," in a few years they almost entirely ceased. (See Appendix.)

1865. This year, by 28 and 29 Vic. c. 66, an important change in the law was instituted, to enable maltsters to malt by weight, by consenting to certain restrictions, such as giving due notice of an intention to wet by weight; a maltster must have a cover affixed to the cistern, which, when filled, was locked, the officer keeping the key. The weight having been duly declared and entered, was then to be verified by the maltster, the standard weight of a bushel being fixed at 53 lbs. But the rest of the Act is too well known to need any lengthened description.

Sept. 30, 1880. All previous Acts repealed, the Malt Tax totally abolished, and a Beer Duty substituted of 6s. 3d. per barrel of 36 gallons, of a standard gravity of 10·57, less 6 per cent.

The object of this chapter is chiefly to point out a few of the more important changes the trade has had to suffer for many centuries through restrictive laws, which have had the effect of making malting the one industry which has progressed in scientific development less than any of similar magnitude in Great Britain.

CHAPTER IV.

EXTRACTS FROM OLD BOOKS ON MALTING.

Tryon's "New Art of Brewing Ale and Other Malt Liquors."—"The London and Country Brewer," &c.—Burns' "John Barleycorn."

PARALLEL to these legal notices we may place and profitably peruse a few full extracts from the literature of the profession from the year A.D. 1690:—

"The New Art of Brewing Beer, Ale, and other Sorts of Liquors." (London: 1691. Thos. Salisbury, Printer.) By Tho. Tryon, Student in Physick. Pages 45—57.

"WHAT WATER IS BEST TO MAKE MAULT.—Running or River Water is to be preferred before either Spring, Well, or Pond Water, which do contain a certain Unctious Virtue, or Saline Fatness, that it attracts or draws from the surface of the Earth, from which good quality and sweet virtues all vegitations do grow and proceed; besides River Waters have not only the benefit of motion, but also the benevolent Influences of the Cœlestial Bodies running in the open Air and Light of Heaven, which do by its fine vapours penetrate and purge it from its harsh Earthy Qualities, and as it were open its cold body, warming and inducing it with a spirituous Airy, and Balsamick virtue, of a soft Nature and Friendly Operation, this being the cause why river water will perform all preparations in House-wifery better, and to more advantage than either spring, well or Pond water, therefore it is the principal water to make your Mault with, for these good virtues and Salinteral quality do never wholly depart from the Mault that it hath indued it withal; besides, this water does more naturally open and penetrate the Body of the Corn with a cartine, mild, and sweet violence; the next in Goodness to this is Spring Water, but remember to Avoid all cold constringent Waters, such as will not wash, for such are of a Saturnine, Earthy, harsh nature and operation, and they do equally indue all things that it doth prepare with its ill qualities, as the former do with their good. If you water your Garden with Well water which is hard, hungry, lean, and harsh, and with running, or River Water, there will be a manifest difference; the first hardens the Earth, and causes the vegitations to dwindle, and if they be tender plants, it often kills them, but the latter will not constringe or bind the Earth, but rather make it plump and hollow, and the plants or Herbs will grow amain, but Rain Water hath the first place of all others, if it could be procured undefiled and simple."

"II. OF MAULT AND HOW IT IS MADE.—To make Mault with judgement is none of the smartest part of Chymistry, some say that it was first invented in Egypt by the Egyptian Phylosophers; but the greatest of mysteries, when commonly Known, are not admired. First put your barley into a Cistern, then fill it with Water that it swims two or three inches above your Corn, the time of this Infusion is according as the Season is either hot or Cold, also according to the Goodness and Nature of the Corn. Some will infuse and Work more kindly than others; your smooth, plump weighty Corn does best, and will embibe or receive the Water more aptly, but your hungry, lean, flinty, thin Barley, will not infuse so Kindly, the which must be left to the Judgement of the Workman; if the Weather be warm two days and three nights may be, in moderate weather three days and three nights, but in winter, especially in Cold Frosty seasons, five or six days will do it no harm. The general way or mark to Know when it is infused or Steeped enough is to take a Corn endways between your fingers, and gently bruise or Crush it, and if you find it equally Mellow, and that the Husk opens, or as it were a little starts from the body of the Corn, then it is Enough, but if your Barley be grown, or any wet have injured it, then be careful that you do not infuse it too much, which is oftentimes done, which do flatten, dull, and wound the Spirituous qualities or sweet vertues, and such Mault will yield but little Spirit or sweetness, and the Drink made thereof will have an ill flat taste, not brisk nor lively, neither will it keep, but quickly grow dead and sour; for the well and long keeping of Beer or Ale depends as much on the goodness of the Mault as Brewing; also you must remember to let your Water drein very well and equally from your Corn, before you take it out of the Cistern 12 or 14 hours in moderate weather, but 24 or 30 in Cold, especially in very Cold, the better the water is dreined from your Corn the more equal it will grow or come, then couch or heap it, if your quantity be large and weather warm, into two, but if cold into one, turn it every 4, 5, 6, 7, or 8 hours, as the Season is either hot or cold, viz., the outwardmost part inwards, and the bottom upwards, and keep your Floor clear, that the Corn that lies next thereunto may not be chilled, and so soon as it begins to Come or as some calls it Work, then turn it oftener, every 3, 4 or 5 hours as you did before, and as even as possible, both day and night if you see occasion, more especially if the weather be cloudy, warm and windy, for the Air is the root of life, and when it is agitated, it awakens and blows up the inward life, and kindles its spirits, that it becomes more brisk and fuller of motion, and as it comes or works more and more so you must by degrees spread and thin your couch or heap wider and wider to cool, and as it were to fix it, that it may not come too much nor too fast, and when it is come, or growed enough, which all that are fit for this Implogment may easily judge, then spread it very thin, and keep turning of it 12, 14, or 16 times in 24 hours, especially if the Season be warm, or late in the Spring, as in March, April or May; great care ought to be taken in the Spring season, for all things then have a more lively motion than at other Seasons, and when you have fixed it, or that the root begins to be dead, then you must thicken it again upon the Floor, but be careful to keep it often turning and working; that the growing of the root may not revive, your shooes ought not to be on your feet; also let your judgement and Diligence be such in working and turning your Mault, and keeping your Floor clear, that it may neither mould nor Ackerspier, that is, the blade to grow out, at the opposite end to the Root, which will mightily lesson the good qualities, and sweatness of the Mault, and also to give the Drink an ill taste. Now being come to this degree, and fit for the kill, some will turn it up into a great heap, 24 or 30 hours, in which time it will heat, which is very prejudicial, and does in a degree Suffocate and flatten the sweet virtues; this, and high drying gives your Beer and Ale a high martial Colour, both which are great violences to nature, and the Drink made thereof, proves injurious to the Drinkers; it sends Fumes and cloudy vapours into the Crown, hurts the Eyes, heats the Blood and a great Friend to the Stone and Gravel, with several other ill Operations. Note, the time of its preparation from the Cysturn to the Kill is uncertain, and according to the Season of the Year, whether hot or cold, and the goodnes of the Corn; in moderate season it will come to the Kill in three weeks or thereabouts, but in cold it may be four or five, and as to the thickness and thinness on your Kill, Men's Judgements vary, and in several countries they have several fashions and customs. Some will put it from seven to ten, or twelve inches thick, which is an ill custom, and it never fails to injure the Mault, for you must keep a strong violent fire, which is apt to burn that which lies next the cloth, while that which is uppermost is neither hot nor cold, which do mightily flatten the spirituous sweet virtues thereof; besides all the diligence you can use cannot dry it so equally, and the thickness thereof occasions it to send forth a terrible damp or moist gross Excrementitious vapour or steem, which do oftentimes re-enter the Mault, wounding and suffocating the finer virtues and sweet Qualities, which gives an ill taste to the Mault and drink made thereof; besides it will make but little drink, and that not good nor wholesome, and if strong Drink be made of such Mault its evil juices are the more perceptable by heating the Body, and stupifying the sences by its gross heavy Fumes, being a great enemy to Nature. These ill Customs all Mault-makers ought to understand and avoid, for every ill Custom and Disorder in making of Mault is tasted and felt in the Drink, and it is most certain, that, through England there is not one bushel of Mault in four made as it ought, viz., to that degree of goodness, which is the occasion that Ale and Beer have so many ill Tastes, and Operations, and that it makes so little drink and weak. Now as to its thickness on the Kill, it ought not to lie more than three, four, or five inches, and let your Fire be constant, not too Fierce, and yet indifferent brisk, which will Keep the Spirit and Life of your Mault living, for it may be as well too slack or slow, as too fierce or strong; for when your Fire is too weak, it flattens and dulls the spirituous sweet exhillerating Qualities, and when it is too strong or fierce, it fires and stagnates them; keep turning of it every two, three, or four hours, and keep your Cloth clear: Also it is to be noted, that your Kill ought to have convenient windows, that the Gross Steams, fulsom Damps, and stupifying Vapours may pass freely away and to let in the friendly Air, which will keep all the real good virtues of the Mault living.

"Now, as to the Complexion or colour of Mault, white is the best, because most natural, and therefore in all preparations and operations you ought, as near as possible you can, to maintain the natural complexion of the thing, for the tinctures ariseth, and proceeds from the fine spirits and essential virtues; therefore, if in your order of making Mault, you alter and change the colour, you then also change its virtues, and make the Drink of another nature and operation; for all redness, or high Colour in Drink proceeds from some violence done to the Spirits and fine virtues in the preparation, for the colour is a stranger to the nature of that grain, and it shows that the fierce Spirits and hot vapours of the fire, have as it were transmuted or changed the mild friendly soft Virtues and Qualities of the Mault, into its own fiery nature; and it is not to be doubted, but that Dijestion is most natural that preserves the tincture entire, force not Nature out of her way, nor change the form, for then the inward Life and good qualities of that thing are in danger; for the fierce raging spirits of the fire, and Essences thereof do never depart from such parched high dried Mault, but do always remain, from whence the Drink made thereof receives its high bloody Colour, which most ignorant people cry up and admire as a virtue, or good quality, but the contrary is to be understood, and nothing in Mault is a greater Vice or Evil, and the Drink made thereof, together with its losing boiling with Hops, do seldom fail to wound the Health of the Drinkers thereof; its natural operation in the body, is to heat the Blood, destroying Appetite, obstructs the Stomach, sending gross dulling Fumes into the head, dulls the fine pure spirits, hinders the free Circulation of the Blood by Stagnating the Humours, and in the Cholerick and Melancholy Complexions, generates the Stone, Gravel, Gout and Consumption; this sort of Drink is also very injurious to women, especially such as are with Child, or give Suck. In all your preparations of Meats and Drinks use diligence, and do no violence to the internal Virtues or Spirits, which are occult and not perceptable to the Eye, therefore if you have not Wisdom and Understanding to distinguish the inward Virtues and Qualifications, and what properties governs in each thing; you may as it were insensibly commit great Errors in the Smallest and Meanest Preparations, as indeed most do for want of an inward understanding of the forms of Nature; and remember this that the nearer you come to Nature, and the more you imitate her, the nearer you are to Truth. Now as to Barley, God and His Handmaid Nature have signed and indued it with that most Amiable Colour White, which of all Colours and Complexions have the first place; therefore in your Preparation and Digestion of Mault use no violence that may cause it to degenerate, but on the contrary, use all Art and Means to maintain it, for the whiter your drink is the better and more healthful, having a mild or gentle Operation; it is not so apt to send dulling, gross thick Fumes and Vapours into the head, nor to heat the Blood, or obstruct the passages; and I must here tell you one truth; namely, that White Ale of a middle strength drank new have the first place of all firmented Drinks, and is the best against the Generation of the Stone, Gravel, and Gout, *excepting good, mild, soft Water,* which is the radix of all moist nourishment.

" There is another Error in the drying and Killning of Mault, there being but few that do keep their Kills so free from Smoak as they ought, for Smoak being extremely prejudicial to the Mault, and also to such as shall drink the Beer or Ale made thereof; for if this stupifying, keen, Fume or Vapour be not prevented from passing through and incorporating with the Mault, which is by its preparation made easily penetrable, and is therefore presently hurt or wounded by this sharp, keen, fulsome, gross vapour, which is full of Dark Sulpheros Excrements, which the Fire and Light casts forth as an Abomination, being void of all real Virtues, containing a gross Humidity, and fierce keen quality, very pernicious to the Health; for Smoak proceeds from the poisonous juices, and original Liquor which the Fire and Air sends forth for the Fire devides and seperates the Forms and Properties of Nature, and manifests what qualities, both Vices and Virtues, that lie in the Root, which so long as the thing remained intire, nothing of this poysonous quality was seen or known, Smoak being an Excrement or thing that all people endeavour to avoid, as being the most prejudicial to the fine Volatile Spirits, and therefore most offensive to the Eyes, for they are the Gates to the whole Body, where the Natural Spirits have their ingress, egress, and regress; and for this cause, Smoak does first offend the eyes, or any other Stupifying Fume or Vapour, either externally or internally, and therefore when anyone shall eat ill-prepared Foods or Drink the like Drinks, when the Natural Heat of the Stomach, and Concoctive Faculty does separate such Food or Drinks, they do as naturally send up into the Head, gross excrementitious Vapours, very offensive to Nature, especially the eyes, (as Coal or Wood does Smoak) the like is to be understood when any shall overcharge their Stomachs with too great a quantity of Meats and Drinks; also how inimical it is to Nature is further manifested by its black Sooty substance which it leaves behind it, and by its destroying vegetation, for it contains two poisonous qualities, viz., a strong Bitter, from Mars, and a fulsom astringent from Saturn, its black colour denotes that its predominant quality is from the venomous Centre of Saturn; therefore in the drying of Mault, there ought to be great Care taken that it be not Smoaked, for Smoak does also help to advance that dull, heavy, reddish colour in Drink, which to avoid. Stones are good and profitable for that purpose, being placed in the midst of your Kill that the heat may equally distribute itself to all parts, all the Smoak being conveyed away by a Funnel aptly placed; when your Mault is dry, let it not cool on the Kill, but presently throw it off, not in a heap, but spread it wide in an airy place until it be thorough cool, then heap it, or otherwise dispose of it. But the best and most natural way of drying Mault is in the Sun in April or May, especially for those that makes but small Quantities for their own use, this makes, not only the palest, but the most Kindly and Wholesome of all others; the Drink made thereof has a delicate fine mildness, being of a warming exhilerating quality, not so apt to heat the Body, nor send Fumes into the Head. In all hot Seasons it may be done, every Man may dry enough for his own use; also it may be done to great advantage in hot Climates, as in Barbadoes; their Indian Corn will make very good Mault, and consequently good Ale, but it must have a few Hops in it. Of Late, some have covered over their Kills with Wyer instead of Hair-cloth, which is much the better way, which doth not only dry it sooner, but cleaner and much sweeter; for by means of this grate, as one may call it, the properties of the Fire passeth away more freely, and the sweetening Vapours of the Air are not so much hindered from circulating, and therefore not so much humidity contracted; but their Cloaths are thick, which prevents the fiery Sulpherous Vapours from passing Away, so that these raging Vapours and fiery Spirits are as it were beat back, and there they with great violence seek their Centre whence they proceed, that is, re-enter the Fire, but finding no agreeable Matter or Body to incorporate, they become the more intense and raging, do with a rapid motion ascend, by which means the Heat which comes through the cloth, is still the more stupifying, sulpherous, gross and hurtful to the Mault, as is most Manifest by the Airs in all close places, as where Stoves are, the Air having no free Circulation; besides they are more cleanly and apt for all good purposes, and your Mault will be whiter, and afford more lively brisk spirits. It is further to be noted, that most people are of opinion that Mault does brew to the greatest advantage, and make Stronger and more Drink if they grind it 5, 6, 7, or 8 days or more before they Brew; for, say they, that the Mault lying some time together after ground, do occasion its dryness and hardness to give, and as it were, become mellow or yielding, by which means it is the easier dissolved, and the hot Liquor does the more aptly penetrate all parts thereof; which is all true, and yet you have no real advantage thereby, but the contrary is to be understood; for as I have told you before, the gross body is but the House, or a covering place for the fine spirituous Vertues, which inward powers are not perceptable unto your sight, and if you by any undue order or method of digestion offer violence to them then immediately these spirituous qualities will according to the degrees of the injury done, evaporate in an invisible breath or air, and then the Body, be what it will, becomes sick, and by degrees will die and perish. As for example, Take a Quart of lively brisk Beer or Ale, warm it well, then set it by for 3 or 4 hours, and you will find that it will have lost all its sparkling lively good qualities and spirits, and yet you have your Measure, it hath not lost any of its quantity, but only in quality. The like is not to be understood in all other things, according to the nature of each, more especially those things that have passed through any Digestion and Fermentation as Mault hath, whose Body is thoroughly opened, which have unlocked all the doors of the harsh astringent chambers of Saturn and Mars, and thereby have, as it were, set at liberty the sweet exhilerating spirituous Vertues of Sol and Venus, that on every affront or violence done them they are on the wing, therefore Mault if ground 5, 6, 7, or 8 days before it be used, the spirituous parts and best virtues will evaporate, no Art can prevent it, and such Mault will not make so much Drink, nor so good as that which is new ground, for when the Body is broken, the Spirits is so nimble or volatile, that there is no Vessel so close that will retain them, and if the Vessel could, the Spirits are so fine and tender, that they will be strangled or suffocated, nothing can hold or contain them, but its own Body, or a proper Menstruum, for this Cause Mault ought not to be ground above 6, 8, or 10 hours before you put it into your Mash-tub, which will afford a better, stronger, and a more spirituous Liquor or Wort, than that which lies ground 6, 7, 8, or 10 days before you Brew, nothing but practice will convince the unlearned; Ill customs have greater power over Mankind, than either the Law of God or Nature, *but Wisdom is justified of her children.*"

Two generations later, "A person formerly concerned in a Public Brewhouse in London"* wrote a volume of 332 pp., that ran through seven editions. Only nine pages of this book were devoted to malt.

As these books are rare, and now appear quaint and antiquated, I will give the nine pages in full (pp. 5-14).

It is well to observe that in nearly all the apparently absurd notions of the past, a certain substratum of fact underlies the ignorance and nonsense expressed.

Probably the most mischievous writer upon the subject was Combrune, who, although he wrote a book of much value, conducted and recorded experiments relating to temperatures of drying malt, which continue to produce evil at the present day. His works, together with Reynoldson's, Steel's, Levesque's, Tizard's, and numerous other modern writers, are still easily obtained.

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* The London and Country Brewer. A New Treatise on Liquor. London, 1759.

"OF MAKING MALT. By a Person formerly concerned in a public Brewhouse in London.—As I have described the Ground that returns the best Barley, I now come to treat of making it into Malt; to do which, the Barley is put into a leaden or tiled Cistern, that holds five, ten, or more Quarters, that is covered with Water, four or six Inches above the Barley, to allow for its Swell; here it lies five or six Tides, as the Maltster calls it, reckoning twelve Hours to the Tide, according as the Barley is in Body or in Dryness; for that which comes off Clay, or has been washed and damaged by Rains, requires less Time than the dryer Grains that was inned well, and grew on Gravels or Chalks; the smooth plump Corn imbibing the Water more kindly, when the lean and steely Barley will not so naturally; but to know when it is enough, is to take a Corn, end-ways, between the Fingers, and gently crush it, and if it is in all Parts mellow, and the Hulk opens, or starts a little from the Body of the Corn, then it is enough. The Nicety of this is a material Point; for if it is infused too much, the sweetness of the Malt will be greatly taken off, and yield the less Spirit, and so will cause Deadness and Sourness in Ale or Beer in a short Time, for the Goodness of the Malt contributes much to the Preservation of all Ales and Beers. Then the Water must be drained from it very well, and it will come equal and better on the Floor, which may be done in twelve or sixteen Hours in temperate Weather, but in cold near thirty. From the Cistern, it is put into a square Hutch or Couch, where it must lie thirty Hours, for the Officer to take his Gage, who allows four Bushels in the Score for the swell in this or the Cistern; then it must be worked Night and Day in one or two Heaps, as the Weather is cold or hot, and turned every four, six, or eight Hours, the outward Part inwards, and the Bottom upwards, always keeping a clear Floor, that the Corn that lies next to it be not chilled; and as soon as it begins to come or spire, then turn it every three, four, or five Hours, as was done before, according to the Temper of the Air, which greatly governs this Management, and as it comes or works more, so must the Heap be spreaded and thinned larger to cool it. Thus it may lie and be worked on the Floor in several Parallels, two or three Feet thick, ten or more Feet broad, and fourteen or more in Length, to chip or spire, but not too much nor too fast; and when it is come enough, it is to be turned twelve or sixteen Times in twenty-four Hours, if the Season is warm, as in March, April, or May; and when it is fixed, and the Root begins to be dead, then it must be thickened again, and carefully kept often turned and worked, that the Growing of the Root may not revive, and this is better done with the Shoes off than on, and here the Workman's Art and Diligence in particular is tried, in keeping the Floor clean, and turning the Malt often, that it neither moulds nor aker-spires, that is, that the Blade does not grow out at the opposite end of the Root; for, if it does, the Flower and Strength of the Malt is gone, and nothing left behind but the Acre-spire, Husk, and Tail. Now when it is at this Degree, and fit for the Kiln, it is often practised to put it into a Heap, and let it lie twelve Hours before it is turned, to heat and mellow, which will much improve the Malt if it is done with moderation, and after that Time it must be turned every six Hours during twenty-four; but if it is over-heated, it will become like Grease and be spoiled, or at least cause the Drink to be unwholesome. When this Operation is over, it then must be put on the Kiln, to dry four, six, or twelve Hours, according to the Nature of the Malt, for the pale Sort requires more Leisure, and less Fire than the amber or brown Sorts. Three Inches thick was formerly thought a sufficient Depth for the Malt to lie on the Hair-cloth, but now six is often allowed it to a Fault; fourteen or sixteen Feet square will dry about two Quarters, if the Malt lies four Inches thick, and here it should be turned every two, three, or four Hours, keeping the Hair-cloth clear. The Time of preparing it from the Cistern to the Kiln is uncertain, according to the Season of the year, in moderate Weather, three Weeks are often sufficient. If the Exciseman takes his Gage on the Floor, he allows Ten in the Score, but he sometimes gages in Cistern, Couch, Floor, and Kiln, and where he can make most, there he fixes his Charge. When the Malt is dried, it must not cool on the Kiln, but be directly thrown off, not into a Heap, but spreaded wide in an airy Place, till it is thoroughly cool, then put it into a Heap, or otherwise dispose of it.

" There are several Methods used in drying of Malts, as the Iron plate-Frame, the Tile Frame, that are both full of little holes: The Brass-wired and Iron-wired Frame, and the Hair-cloth; the Iron and Tiled ones were chiefly invented for drying of brown Malts, and saving of Fuel, for these, when they come to be thoroughly hot, will make the Corns crack and jump by the Fierceness of their Heat, so that they will be roasted or scorched in a little Time, and after they are off the Kiln, to plump the Body of the Corn, and make it take the Eye, some will sprinkle Water over it, that it may meet with the better Market. But if such Malt is not used quickly, it will slacken and lose its Spirits to a great Degree, and perhaps, in half a Year or less, may be taken by the Whools and spoiled: Such hasty Dryings, or Scorchings, are also apt to bitter the Malt, by burning its Skin, and therefore these Kilns are not so much used now as formerly. The Wire Frames indeed are something better, yet they are apt to scorch the outward Part of the Corn, that cannot be got off so soon as the Hair-cloth admits of, for these must be swept when the other is only turned at once; however, these last three ways are now in much Request for drying pale and amber Malts, because their Fire may be kept with more Leisure, and the Malt more gradually and truer dried, but by many the Hair-cloth is reckoned the best of all.

"Malts are dryed with several Sorts of Fuel: as the Coak, Welch-coal, Straw, Wood, and Fern, and etc. But the Coak is reckoned by most to exceed all others for making Drink of the finest Flavour and pale Colour, because it sends no Smoak forth to hurt the Malt with any offensive Tang, that Wood, Fern, and Straw are apt to do in a lesser or greater Degree; but there is a Difference even in what is called Coak, the right Sort being large Pit-coal charked or burnt in some Measure to a Cinder, 'till all the Sulphur is consumed and evaporated away, which is called Coak, and this, when it is truly made, is the best of all other Fuels; but if there is but one Cinder as big as an Egg that is not thoroughly cured, the Smoak of this one is capable of doing a little Damage, and this happens too often by the Negligence or Avarice of the Coak maker: There is another Sort, by some wrongly called Coak, and rightly named Culm or Welch-coal, from Swanzey in Pembrokeshire, being of a hard stony Substance, in small Bits, resembling a shining Coal, and will burn without Smoak, and by its sulphureous Effluvia cast a most excellent Whiteness on all the outward Parts of the grainy Body: In Devonshire I have seen their Marble or grey Fire-stone burnt into Lime with the strong Fire that this Culm makes, and both this and the charked Pit-coal afford a most sweet, moderate, and certain Fire to all Malt that is dried by it.

"Straw is the next sweetest Fuel, but Wood and Fern worst of all.

"Some I have known put a Peck or more of Pease, and malt them with five Quarters of Barley, and they will greatly mellow the Drink, and so will Beans; but they won't come so soon, nor mix so conveniently with the Malt, as the Pea will.

"I know a Farmer, when he sends five Quarters of Barley to be malted, puts in half a Peck or more of Oats amongst them, to prove he has Justice done him by the Maker, who is hereby consined not to change his Malt, by reason Others won't like such a Mixture.

"But there is an Abuse sometimes committed by a necessitous Maltster, who, to come by Malt sooner than ordinary, makes Use of Barley before it is thoroughly sweated in the Mow, and then it never makes right Malt, but will be steely and not yield a due Quantity of Wort, as I knew it once done by a Person that thrashed the Barley immediately from the Cart as it was brought out of the Field, but they that used its Malt suffered not a Little, for it it was impossible it should be good, because it did not thoroughly chip or spire on the Floor, which caused this Sort of Malt, when the Water was put to it in the Mash-tub, to swell up and absorb the Liquor, but not return its due Quantity again, as true Malt would; nor was the Drink of this Malt ever good in the Barrel, but remained a raw, insipid Beer, past the Art of Man to cure, because this like Cyder made from Apples directly off the Tree, that never sweated out their phlegmatic crude Juice in the Heap, cannot produce a natural Liquor from such unnatural Management;

for Barley certainly is not fit to make Malt of 'till it is fully mellowed and sweated in the Mow, and the Season of the Year is ready for it, without both which there can be no Assurance of good Malt: Several Instances of this untimely making Malt I have known to happen; that has been the Occasion of great Quantities of bad Ales and Beers; for such Malt retaining some of its Barley Nature, or that the Season of the Year is not cold enough to admit of its natural Working on the Floor, is not capable of producing a true Malt, but will cause its Drink to stink in the Cask instead of growing fit for use, as not having its genuine Malt Nature to cure and preserve it, which all good Malts contribute to as well as the Hop.

"There is another Damage I have known to accrue to the Buyer of Malt by Mellilet, a most stinking Weed that grows among some Barley, and is so mischievously predominant, as to taint it to a bad Degree, because its black Seed, like that of an Onion, being lesser than the Barley, cannot be intirely separated, which obliges it to be malted with the Barley, and makes the Drink so heady, that it is apt to fuddle the Unwary by drinking a small Quantity: This Weed is so natural to some Ground, that the Farmer despairs of ever extirpating it, and is to be avoided as much as possible, because it very much hurts the Drink that is made from Malt mixed with it, by its nauseous Scent and Taste, as may be perceived by the Ointment made with it that bears its Name: I knew a Victualler that bought a Parcel of Malt that this Weed was amongst, and it spoiled all the Brewings and Sale of the Drink, for it is apt to cause Fevers, Colics, and other Distempers in the Body.

"Darnel is a rampant Weed and grows much among some Barley, especially in the bad Husbandman's Ground, and most where it is sown with the Seed-barley: It does the least Harm amongst Malt, because it adds Strength to it, and quickly intoxicates, if there is much in it; but where there is but little the Maltster regards it not, for the Sake of its inebriating Quality. There are other Weeds or Seeds that annoy the Barley, but as the Screen, Sieve, and Throwing will take most of them out, there does not require here a Detail of their Particulars. Oats, malted as Barley is, will make a weak, soft, mellow, and pleasant Drink; but the Wheat, when done so, will produce a strong, heady, nourishing, well-tasted, and fine Liquor, which is now more practised than ever.

"TO KNOW A GOOD FROM BAD MALT.—This a matter of great Importance to all Brewers, both public and private, for it is common for the Sellers to cry, All is good, but the Buyer's Case is different: wherefore it is prudential to endeavour to be Masters of this Knowledge; for I have heard a great Maltster that lived towards Ware say, he knew a grand Brewer, that wetted near two hundred Quarters a Week, was not a Judge of good and bad Malts, without which it is impossible to draw a true Length of Ale or Beer. To do this, I know but of few Ways, First, By the Bite; is to break the Malt-corn across between the Teeth, in the Middle of it or at both ends, and if it tasteth mellow and sweet, has a round Body, breaks soft, is full of Flour all its Length, smells well, and has a thin Skin, then it is good. Secondly, By Water; is to take a Glass near full, and put in some Malt, and if it swims, it is right, but if any sinks to the Bottom, then it is not true Malt, but steely, and retains somewhat of its Barley Nature; yet I must own this is not an infallible Rule, because if a Corn of Malt is cracked, split, or broke, it will then take the Water and sink, but there may an Allowance be given for such Incidents, and still Room enough to make a Judgment. Thirdly, Malt, that is truly made, will not be hard and steely, but of so mellow a Nature, that if forced against a dry Board, will mark, and cast a white Colour almost like Chalk. Fourthly, Malt that is not rightly made will be Part of it of a hard Barley Nature, and weigh heavier than that which is true Malt.

"OF THE NATURE AND USE OF PALE, AMBER, AND BROWN MALTS.—The pale Malt is the slowest and slackest dried of any, and where it has had a leisure Fire, a sufficient Time allowed it on the Kiln, and a due Care taken of it, the Flour of the Grain will remain in its full Quantity, and thereby produce a greater Length of Wort, than the brown high dried Malt, for which Reason it is sold for one or two Shillings per Quarter more than that; This Pale Malt is also the most nutritious sort to the Body of all others, as being in this State the most simple and nearest to its original Barleycorn, that will retain an alcalous and balsamic Quality much longer than the brown Sort; the tender Drying of this Malt bringing its Body into so soft a Texture of Parts, that most of the great Brewers brew it with Spring and Well-waters, whose hard and binding Properties they think agree best with this loose-bodied Malt, either in Ales or Beers, and which will also dispense with hotter Waters in brewing of it, than the brown Malt can.

"The amber-coloured Malt is that which is dried in a medium Degree, between the Pale and the Brown, and is very much in Use, as being free of either Extreme. Its Colour is pleasant, its Taste agreeable, and its Nature wholesome, which makes it to be preferred by many as the best of Malts; this by some is brewed either with hard or soft Waters, or a Mixture of both. The brown Malt is the soonest and highest dried of any, even till it is so hard, that it is difficult to bite some of its Corns asunder, and is often so crusted or burnt, that the farinous Part looses a great deal of its essential Salts and vital Property, which frequently deceives its ignorant Brewer, that hopes to draw as much Drink from a Quarter of this, as he does from Pale or Amber Sorts: This Malt, by some, is thought to occasion the Gravel or Stone, besides what is commonly called the Heart-burn; and is by its steely Nature less nourishing than the Pale or Amber Malts, being very much impregnated with the fiery fumiserous Particles of the Kiln, and therefore its Drink sooner becomes sharp and acid than that made from the Pale or Amber Sorts, if they are fairly brewed: For this Reason the London Brewers mostly use the Thames or New-

River Waters to brew this Malt with, for the Sake of its soft Nature, whereby it agrees with the harsh Qualities of it better than any of the Well or other hard Sorts, and makes a luscious Ale for a little While, and a But-beer that will keep very well five or six Months, but after that Time it generally grows stale, notwithstanding there be ten or twelve Bushels allowed to the Hogshead, and it be hopped accordingly.

"Pale and Amber Malts dried with Coak or Culm, obtain a more clean, bright, pale Colour, than if dried with any other Fuel, because there is not Smoak to darken and sully their Skins or Husks, and give them an ill Relish, that those Malts little or more have, which are dried with Straw, Wood, or Fern, etc. The Coak or Welch Coal also makes more true and compleat Malt, as I have before hinted, than any other Fuel, because its Fire gives both a gentle and certain Heat, whereby the Corns are in all their Parts gradually dried, and therefore of late these Malts have gained such a Reputation that great Quantities have been consumed in most Parts of the Nation for their wholesome Natures and sweet fine Taste. These make such fine Ales and But-beers, as has tempted several of our Maltsters in my Neighbourhood to burn Coak or Culm at a great Expense of Carriage thirty Miles from London.

"Next to the Coak-dried Malt, the Straw-dried is the sweetest and best tasted: This, I must own, is sometimes well malted, where the Barley, Wheat, Straw, Conveniences, and the Maker's Skill are good; but as the Fire of the Straw is not so regular as the Coak, the Malt is attended with more Uncertainty in its Making, because it is difficult to keep it to a moderate and equal Heat, and also exposes the Malt in some Degree to the Taste of the Smoak.

"Brown Malts are dried with Straw, Wood, and Fern, etc. The Straw-dried is far the best, but the Wood-sort has a most unnatural Taste, that few can bear with, but the Necessitous, and those that are accustomed to its strong smoaky Tang; yet it is much used in some of the Western Parts of England, and many thousand Quarters of this Malt have been formerly used in London for brewing the Butt-keeping Beers with, and that because it sold for two Shillings per Quarter cheaper than the Straw-dried Malt; nor was this Quality of the Wood-dried Malt much regarded by some of its Brewers, for that its ill Taste is lost in nine or twelve Months, by the Age of the Beer, and the Strength of the great Quantity of Hops that were used in its Preservation.

"The Fern-dried Malt is also attended with a rank disagreeable Taste from the Smoak of this Vegetable, with which many Quarters of Malt are dried, as appears by the great Quantities annually cut by Maltsters on our Commons, for the two prevalent Reasons, Cheapness and Plenty.

"At Bridport in Dorsetshire I knew an Inn-keeper use half Pale and half Brown Malt for brewing his Butt-beers, that proved to my Palate the best I ever drank on the Road, which

I think may be accounted for, in that the Pale being the slackest, and the Brown the hardest dried, must produce a mellow good Drink, by the Help of a requisite Age, that will reduce those Extremes to a proper Quality."

Later, considerable strides were made in the actual scientific comprehension of changes effected in grain by the malting process. Unfortunately, our own countrymen confined themselves very largely to mere practical modes of working. As these were chiefly unscientific and ignorant, we may at once pass over succeeding writers, but care has been taken to record and tabulate the opinions and usages of a number of them in the different chapters, especially in those cases where the opinions and experiences of good practical men are still of use. For a lengthened list of works, see Bibliography, chapter xix.

I can, however, scarcely conclude this chapter without quoting the poetical description of malting given by Burns.

JOHN BARLEYCORN.*

A BALLAD.

I.

There were three kings into the east,
Three kings both great and high,
And they hae sworn a solemn oath
John Barleycorn should die.

II.

They took a plough and ploughed him down,
Put clods upon his head,
And they hae sworn a solemn oath
John Barleycorn was dead.

III.

But the cheerful spring came kindly on,
And show'rs began to fall;
John Barleycorn got up again,
And sore surprised them all.

IV.

The sultry suns of summer came,
And he grew thick and strong,
His head well armed with pointed spears,
That no one should him wrong.

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* This is partly composed on the plan of an old song known by the same name.

V.

The sober autumn entered mild,
When he grew wan and pale;
His bending joints and drooping head
Showed he began to fail.

VI.

His colour sickened more and more,
He faded into age,
And then his enemies began
To show their deadly rage.

VII.

They've ta'en a weapon long and sharp,
And cut him by the knee,
Then tied him fast upon a cart
Like a rogue for forgerie.

VIII.

They laid him down upon his back,
And cudgelled him full sore;
They hung him up before the storm,
And turned him o'er and o'er.

IX.

They filled up a darksome pit
With water to the brim,
They heaved in John Barleycorn,
Then let him sink or swim.

X.

They laid him out upon the floor
To work him farther woe,
And still as signs of life appeared
They tossed him to and fro.

XI.

They wasted o'er a scorching flame
The marrow of his bones,
But a miller used him worst of all,
He crushed him 'tween two stones.

[illegible] Pale being the [illegible] produce a [illegible] Age, that will [illegible]

[illegible] actual scientific [illegible] by the malting [illegible] confined themselves [illegible] working. As [illegible] we may at once [illegible] taken to record [illegible] a number of them in [illegible] cases where the [illegible] are still of use. [illegible] chapter xix. [illegible] chapter without [illegible] by Burns.

[illegible]*

[illegible]

I.

There went three kings into the east,
Three kings both great and high,
And they hae sworn a solemn oath
John Barleycorn should die.

II.

They took a plough and ploughed him down,
Put [illegible] upon his head,
And they hae sworn a solemn oath
John Barleycorn was dead.

III.

But the cheerful spring came kindly on,
And show'rs began to fall;
John Barleycorn got up again,
And sore surprised them all.

IV.

The sultry suns of summer came,
And he grew thick and strong,
His head well armed with [illegible]
That no one should [illegible]

---

* This is partly composed on the [illegible]

V.

The sober autumn entered mild,
  When he grew wan and pale;
His bending joints and drooping head
  Showed he began to fail.

VI.

His colour sickened more and more,
  He faded into age,
And then his enemies began
  To show their deadly rage.

VII.

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  With water to the brim,
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  Then let him sink or swim.

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They laid him out upon the floor
  To work him farther woe,
And still as signs of life appeared
  They tossed him to and fro.

XI.

Th scorching flame
  is bones,
im worst of all,
  'tween two stones.

XII.

And they hae ta'en his very heart's blood
And drank it round and round,
And still the more and more they drank
Their joy did more abound.

XIII.

John Barleycorn was a hero bold,
Of noble enterprise,
For if you do but taste his blood,
'Twill make your courage rise.

XIV.

'Twill make a man forget his woe;
'Twill heighten all his joy:
'Twill make the widow's heart to sing,
Tho' the tear were in her eye.

XV.

Then let us toast John Barleycorn,
Each man a glass in hand;
And may his great posterity
Ne'er fail in old Scotland!

R. Burns.

PART II.—MATERIALS USED.

◆

CHAPTER V.

AIR, FUELS, ANTISEPTICS, WATER.

Air:—
Influence on Germination. In Drying. Saturation-Limit Tables. Expansion Tables.
Fuels:—
Anthracite Coal. Analyses of Anthracite and Bituminous Coals, Coke, Peat, Oak, Beech, Pine, &c. Tomkins' Kiln. Influence of Products of Combustion. Quantity of Fuel required. Cost.
Antiseptics:—
Sulphur. Causes of Putrefaction. Bisulphite of Lime. Modes of Use, &c.
Water:—
Influences of Water. Hard Water. Soft Water.
Analyses of Steep-Liquor.
Influences of Light. Daubeny's Experiments. Stopes' Experiments on Germination.

MALTING is a decaying industry in Great Britain. The causes of this decay are numerous and not difficult of discovery. For many years the baneful effect of the Malt Tax was regarded as the most fundamental.

If looked at solely from the maltsters' point of view, the total abolition of this tax will only do harm instead of good, as the monopoly held for many years by barley is irrecoverably lost, and many other materials are capable of being used.

The days when malt-drinks were almost exclusively consumed have passed, and the formidable rivalry of light wines and spirits, tea, coffee, cocoa, and, more recently, the innumerable varieties of natural and artificial mineral waters, have rendered the actual production of malt almost stationary, and, relatively to the constant increase of population, retrogressive.

The reduction of the wine-duties has also exerted an appreciable influence upon the consumption of malt, and the rapid spread of temperance principles must not be overlooked.

The increased extract now obtained from malt by more intelligent mashing, and the greater quantity of beer produced by the material reduction of the original gravity of the wort, tend to prevent such an increase in quantity of malt made as should correspond to the greater amount of beer brewed.

Sugar also, as used by brewers of late years, assists very materially to prevent any healthy growth in the malting trade.

Brewing is a progressive art, still very far from even such a degree of perfection as our present knowledge permits. Malt will most probably be used so long as beer is required, and efforts to improve the mode of manufacture will necessarily continue to be made. Whatever other material may be found to be serviceable in brewing, it is so improbable that malt will be abandoned that the question may be at once dismissed.

We may assert, as almost equally probable, that no other material will ever be found to malt so well as barley; still there are numerous other cereals and fruits which have been malted at various times and proved to possess properties more or less valuable to different traders.

The following is a list of the substances convertible into malt for commercial purposes:—

Cereals.	Other Seeds.
Barley	Beans
Maize	Peas
Oats	
Rice	
Rye	
Wheat	

The substances used and agencies employed during the process of malting are very few and simple. They are as follows:—

1. Air. Necessary at all stages until completion of manufacture.
2. Fuel, Sulphur } In kiln
3. Bisulphite of lime, Gypsum, Chalk }
4. Water } In steeping cisterns or upon growing floors.

Air.

Air plays a most important part during all stages of the manufacture of malt, and consequently must, in certain senses, be regarded as one of a maltster's materials. The atmosphere ordinarily contains all that is needed by germinating grain if rightly directed and controlled. Without air, malting, as commonly understood, would be impossible. Nay, further (with one exception only), every process depends entirely upon two conditions of the air, for the power man possesses to convert barley into malt in a practical and commercial manner. These two conditions are temperature and humidity.

The force of such a sweeping general statement will be better understood by perusal of the following suggestions and facts.

Germination does not proceed in a vacuum, nor will corn grow in any mixture of gases in which there is not a considerable percentage of oxygen at the normal pressure of the atmosphere.

A free circulation of air is of the utmost consequence during the growth of barley or other corn upon the floors and kilns during drying.

A proper volume of air is valuable during couching, steeping, and storage of barley.

All air is best excluded during the storage of finished malt.

In a properly arranged malthouse the circulation of the air is so controlled that it may supply a sufficient quantity of oxygen to the barley at all stages, and may also remove the carbonic acid gas and alcohol, usually generated and given off by the sprouting grain.

It is also desirable to allow the grain during the steeping process to have air passing through it at intervals. This can be effected in a variety of ways.

Germination will not progress in air deprived of oxygen, in carbonic acid gas, in air containing oxygen but having over 20 per cent. of carbonic acid; in pure oxygen, in a partial vacuum, or under a heavy pressure of common air equalling 120 lbs. per square inch.

Free contact of air is beneficial during couching, so long as the moisture of the grain is not evaporated to any appreciable extent. A strong current or blast is undesirable during any of the earlier processes in a malthouse. If it be adopted for any reason, then care must be taken to regulate its humidity so as to prevent absorption of moisture by the air from the grain.

The final friability of malt depends very largely upon the nature and amount of air which comes into contact with it at all stages of malting, not excepting the time the barley is soaking in steep.

Grain which has once been sufficiently steeped, flags and withers if dried by too great a volume of air passing over it. Floors turned too frequently, or spread out too thin, are occasionally damaged by inattention on the part of the maltster to so simple and self-evident a fact.

It has been proved experimentally by several great physicists that a grain of corn, when growing, absorbs oxygen and throws off carbonic acid gas. This can only be done if the grain be sufficiently moist. The actual degree of moisture requisite is not yet determined.

Attention to the condition, circumstances, and consequent influences of the air, during the earlier stages of malting, is requisite for the reasons already named. Air, however, is under no circumstances naturally pure in any position in which it is practicable to make malt for sale. We have consequently to take into consideration the fact that all air is filled with germs and organisms of a baneful and undesirable character.

This is a matter of grave significance during the stages of growth of the corn, for the temperature and conditions suitable to the vital existence of the grain are very favourable to the rapid reproduction of the numerous low organisms ever present in air, and to the development of the germs of these organisms.

This factor is probably as important as the increase of temperature in preventing the production of good malt during the summer months. The rapid spread of mould just before withering in some houses is entirely owing to imperfect or improper circulation of the air.

During all the stages of malting, up to loading the kiln, it is desirable to have the air cool and moist. Under no circumstances ought air to be admitted of a temperature exceeding 62° or of a dryness represented by under 70 per cent. of the relative humidity.

When the grain reaches the kiln the conditions are all reversed. Heated air has to be applied at once, and of as great dryness as can be obtained. Doubtless the chief reason why heat is desirable is to be found in the fact that air has its saturation-limits shifted by the accession of each degree of heat. Thus air at 30° is dry, at 60° its normal saturation-point is only six grains per cubic foot, at 90° it is sixteen grains, at 100° it is twenty grains, and so on.

The significance of these figures is not apparent at sight, but in the question of drying moist substances they possess a great value, which is readily seen upon examination of the following hygrometric tables (see p. 39).

It is clear that when a kiln floor is loaded with green malt, certain work has to be performed with two agents, heat and air. We know by experience that each sixty quarters of malt will take about one ton of coal, although many maltsters are too indifferent to the subject to know even so little.

Assuming we have a kiln capable of drying fairly 60 quarters of malt, such a kiln must have floors equal to from 2,100 to 2,400 feet superficial area. We know the malt, when dry, will weigh about 42 lbs. per bushel. Depending upon the way it has been worked and withered, the green malt contains from 30 to 50 per cent. by weight of moisture; assuming it to be 40 per cent., we get $60 \times 8 \times 42 = 20{,}160$ lbs. solid matter and 8,064 lbs. moisture. Every pound of this moisture has to be carried by the ascending current of heated air. During the winter there are many days when the saturation-limit of the air is nearly reached at the natural temperature for the time being; such air, if passed through malt in enormous volumes, would remove the moisture but very slowly, say only one grain per cubic foot of air, consequently requiring 7,000 cubic feet of air to remove one pound of water from the malt. An addition of 50° of heat to this volume of air adds probably 15 grains per foot to its saturative capacity; consequently, 7,000 cubic feet of air at 100° will remove 15 lbs. of water from the malt. As we have 8,064 lbs. of moisture to remove from 60 quarters malt, if our temperature never exceeded 100° and the normal humidity of the air were such that at this heat each pound of water required 466 feet of air to effect its removal, then it follows that we must pass upwards of three and three-quarter millions of feet of air over our malt ($466{\cdot}6 \times 8{,}064 = 3{,}762{,}662$ feet).

If our kiln has an outlet of 20 feet superficial area, and the malt is dried in 50 hours, then the mean average velocity of the air is 627 feet per minute: $\frac{3,762,662}{20 \times 50 \times 60} = 627$ feet.

This is a result never attained in practice, and we know that infinite variations from it constantly occur.

1. The heat is allowed to get considerably over 100°.
2. The percentages of moisture assumed to be present in the green malt may be considerably less.
3. The total volume of moisture is never entirely removed in malts made for sale.

Careful consideration of this subject at once points to the fact, that the higher the temperature of the air passing through moist corn, the greater is its efficiency, and the whole process of drying or sweating is absolutely under control by a proper adaptation of the conditions under which we work to the natural laws governing the absorption of moisture by heated air.*

The following tables of the saturation-limit of air at varying temperatures, and of the expansion of dry air, will be of material use in the consideration of some of the problems connected with drying. (To determine saturation-limit of air, see Chap. XVI., " Hygrometers.")

Table of Weight, in Grains, of the Vapour Absorbable by a Cubic Foot of Dry Air at Varying Temperatures.

Degrees Fahr.	Grains.	Degrees Fahr.	Grains.	Degrees Fahr.	Grains.	Degrees Fahr.	Grains.
90	14·85	135	48·65	175	123·17	215	270·42
95	17·18	140	55·39	180	137·05	220	297·20
100	19·84	145	62·49	185	149·90	225	320·39
105	22·39	150	70·42	190	169·62	230	350·28
110	25·70	155	78·79	195	186·05	235	376·24
115	29·40	160	88·34	200	207·36	240	410·77
120	33·24	165	99·16	205	225·39	245	438·23
125	37·21	170	111·47	210	249·14	250	474·60
130	42·59						

Table of Expansion of Dry Air.

Degrees Fahr.	Cubic Feet whilst dry.	Degrees Fahr.	Cubic Feet whilst dry.	Degrees Fahr.	Cubic Feet whilst dry.	Degrees Fahr.	Cubic Feet whilst dry.
50	1·0000000	135	1 1669485	175	1·2455125	215	1·3240765
100	1·0982050	140	1·1767690	180	1·2553330	220	1·3338970
105	1·1080255	145	1·1865895	185	1·2651535	225	1·3437175
110	1·1178460	150	1·1964100	190	1·2749740	230	1·3535380
115	1·1276665	155	1·2062305	195	1·2847945	235	1·3633585
120	1·1374870	160	1·2160510	200	1·2946150	240	1·3731790
125	1·1473075	165	1·2268715	205	1·3044355	245	1·3829995
130	1·1571280	170	1 2356920	210	1·3142560	250	1·3928200

The preceding tables sufficiently explain the action of heated air in maltings.

FUELS.

The nature and quality of fuel used in the malting are ruled by the character of the malt to be produced.

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* It is of grave importance to remember that the kiln-drying of malt is essentially a cooking process; consequently, the mere drying is not the only end to be attained.

The construction of the kiln, and the method of working adopted, regulate the quantity.

As factors largely influencing both quantity and quality are the greed and ignorance of maltsters.

The fuel used in malthouses during the present century has varied in character. The following list shows this.

- Coke :—
    - Oven coke.
    - Gas coke from common bituminous coal.
    - Gas coke from cannel coal.
- Coal :—
    - Anthracite.
    - Bituminous coal.
- Lignite.
- Peat.
- Wood :—
    - Oakwood billets and faggots.
    - Beechwood.
    - Brushwood.
    - Furze.
- Straw :—
    - Bean, wheat, oat, barley, dried fern.
- Gas.

The best fuel for drying purposes is pure anthracite coal. Good oven coke is of nearly equal value. In many cases a mixture of coke and coal is to be preferred.

Common gas coke, bituminous coal, lignite, peat, brushwood, and straw, should never be used in kilns of common construction.

Oakwood is only used by makers of blown or brown malt.

Beechwood, when rightly used, is of value for flavouring pale and amber malts.

The reasons for the foregoing rules for use of fuel may be found by comparing the analyses on following pages.

Bituminous Coals.[*]

	Hartley, Northumberland.	Brockwell Seam, Brancepeth, Durham.	Silkstone, Yorkshire.	Black Vein, Celynear, Merthyr Tydvil, S. Wales.	
	House.	Coking.	Gas.	Steam.	Peat.
Carbon	84·824	83·40	80·46	85·98	54·1
Hydrogen . ..	5·522	4·40	5·08	4·70	5·6
Oxygen ..	6·223	7·18	6·80	5·53	40·1
Nitrogen .. .	2·075		1·67	0·90	
Sulphur ..	1·181	1·00	1·65	0·59	—
Ash	0·715	3·50	3·30	2·30	4·6
Water	—	0·99	1·04	—	—

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[*] The Coal and Iron Industries of the United Kingdom. By R. MEADE. 8vo. London, 1882.

Welsh Anthracites.[*]

	CAERMARTHENSHIRE.			PEMBROKESHIRE.			GLAMORGANSHIRE.				
	Gwendraeth.	Pontyeats.	Big Vein.	Bonville Court.	Timber Vein.	Watney's (Lyon Playfair).	Brass Vein, Cwmllynfell.	Cwm Neath.	Ystalyfera.	Swansea.	Neath Abbey.
Carbon	92·17	91·16	88·70	94·18	93·00	92·17	91·44	93·12	92·46	89·00	91·08
Hydrogen	3·10	3·11	7·40	2·99	3·08	3·10	3·46	5·22	6·04	7·50	5·01
Oxygen	2·22	2·74		0·50	1·67	2·22	2·58				
Nitrogen	1·08	0·91		0·76	0·54	1·08	0·21				
Sulphur..	0·34	0·86	0·50	0·59	0·68	0·34	0·79				
Ash	1·09	1·12	3·40	0·98	1·03	1·09	1·52	1·50	1·50	3·50	4·00
Total	100·00	99·90	100·00	100·00	100·00	100·00	100·00	99·84	100·00	100·00	100·09

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[*] R. MEADE. *Op. cit.*

Coke.[*]

	Coking Coals, Durham.					Cannel, Cumberland.	Steam Coal, Wales.	Scotch Cannel.			
	Hamsteels.	Consett.	Whitworth.	South Brancepeth.	Dukinfield, Stalybridge.	Dovenby Colliery, Dearham, Maryport.	Black Vein, Merthyr Tydvil.	Lesmahago.	Boghead.	Capeldrea.	Lochgelly.
Carbon	92·55	91·88	91·56	93·41	85·84	57·65	87·92	79·69	29·50	76·52	69·93
Hydrogen	—	—	—	—	0·52	—	4·37	—	—	—	—
Oxygen	—	—	—	—	1·38	—	4·88	—	—	—	—
Nitrogen	—	—	—	—		—	0·51	—	—	—	—
Sulphur..	0·81	0·84	1·21	0·91	0·86	2·02	0·90	2·26	0·25	0·41	0·37
Ash	6·36	6·91	6·69	5·30	11·40	40·33	1·08	18·05	70·25	23·07	29·70
Water	0·21	0·37	0.54	0·36	—	—	—	—	—	—	—

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[*] R. Meade. *Op. cit.*

Sir R. Kane, in "The Industrial Resources of Ireland," 1845, gives (p. 37) an analysis of very dense, compact peat occurring deep in the Wood of Allen bog. Its colour was very dark brown, nearly black, its fracture earthy, almost conchoidal, and it had a resinous lustre when rubbed. No trace of vegetable structure was observable. The specific gravity varied from 0·639 to 0·672, and the composition was as follows:—

Analysis of Peat from Wood of Allen Bog, Ireland.

Carbon	61·02
Hydrogen	5·77
Oxygen	32·40
Nitrogen	0·81
Ash	7·90
	100·00

F. Vaux, in a paper on "The Ultimate Analysis of Some Varieties of Coal,"* gives an analysis of peat from the military prison, Dartmoor, Devonshire. It is fibrous, porous, and brown in colour. When heated it gives out a gas of luminous smoky flame. The coke is in the form of the original peat, but much shrunk. It is lustreless, and of loose texture, and on calcination leaves a bulky, pure white ash, quite infusible with the blowpipe. The specific gravity of the peat is 0·85, and its composition is as follows:—

Analysis of Dartmoor Peat (excluding water 25·56 *per cent.)*

Carbon	54·02
Hydrogen	5·21
Oxygen	28·17
Nitrogen	2·30
Sulphur	0·56
Ash	9·73

The coke amounted to 29·3 per cent. and excluding the ash, water, sulphur, and nitrogen, there remain the following percentages of fuel-elements:—

Carbon	61·81
Hydrogen	5·96
Oxygen	32·23

Analyses of Wood used as Fuel.

	Oak.			Beech.	Pine.
Carbon	47·11	48·12	50·10	49·46	50·62
Hydrogen	6·31	6·06	6·07	5·96	6·27
Oxygen	45·31	44·43	43·68	42·36	42·58
Nitrogen	—	—	—	1·22	—
Ash	1.27	1·37	0·15	1·0	0·53

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* *Quart. Journ. Chem. Soc.* vol. i. p. 318 [1849].

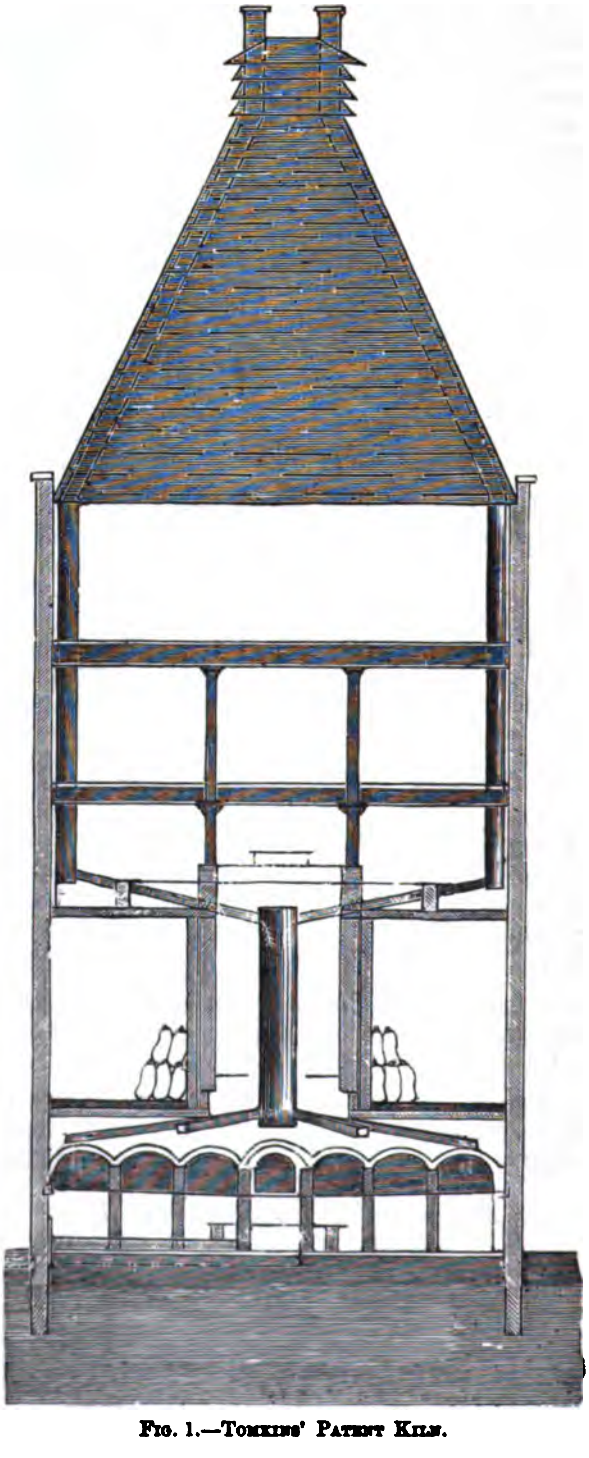

FIG. 1.—TOMKINS' PATENT KILN.

In some cases barley is sweated and malt dried upon kiln floors, to which only heated air has access. These kilns have closed furnaces of many forms. Very good kilns of this class are patented in this country by Messrs. Tomkins, Courage, and Cracknell (fig. 1), and Mr. Seagrave, and one is patented in America by Mr. Buckhardt, Boston.

Any kiln having furnaces of this or similar construction can burn every material capable of giving sufficient heat to the ascending current of air. Users of such kilns are guided in the choice of fuel by the convenience and economy of the material to be burned.

Maltsters using kilns of any description in which it is arranged that a portion or all of the air used by the fire comes into direct contact with the malt, have to pay attention to the influence of the products of combustion upon the malt. One distinguishing character of malt is attributed to this influence. It is sufficient here to class it under the familiar head of empyreumatic flavours. The substances of varied character ever present in fuel necessarily influence these flavours in malt by the various conditions indicated by—

1. The actual and relative temperatures of the malt and air.
2. The composition of the air as influenced by the gases given off by the fuel, or the other solid matters, carried by the force of the ascending currents, and deposited upon the malt.
3. The degree of humidity of the malt.

Bearing these three conditions in mind, it is easy to determine the impropriety of using in any open-fire kiln the following fuels. Straw and dried fern of all kinds, peat, lignite, furze, brushwood, and green wood of all sorts, bituminous coal, gas-coke, or gas. The fuels remaining fit for use are oven-coke, anthracite coal, dry oak, and beechwood.

The proper use of these fuels is ruled by their ascertained composition, and the condition and quality desired in the finished malt.

In the use of wood as fuel, much depends on its dryness, on the supply of air, and on the care of the stoker. If the wood be damp, the air limited, or the fire charged at too rare intervals, much more smoke is produced than is yielded by dry wood, furnished in small quantities, with abundant air, by which the volatile compounds (*i.e.*, unoxidised distillation-products, chiefly resins and acids), if formed, are destroyed at the moment of their evolution. The escape of unoxidised material means, of course, the loss of the heat that its combustion would have yielded, apart from any effect which the condensation of the less volatile substances at the lower temperature of the drying floor may have upon the malt. The "smoke" in Scotch whiskey, for instance, is resinous matter derived from the peat used as malting fuel, more or less modified by the processes of distillation, but characterising the resulting spirit in an unmistakable manner. The actual quality of fuel used is ruled by the construction of the kiln, the mode of drying, the relative temperatures during drying, the quality of the fuel, the hygroscopic condition of the air, and the care of the stoker.

The average consumption of coal in common English single floor malthouses is one ton of coal burned for forty-five quarters of malt. A well-constructed double-floor kiln can dry eighty quarters per ton.

The whole season's average cost for fuel ought never to exceed 4d. per quarter, in all places where coal or coke is to be bought for 25s. per ton.

The fuel used in steam boilers in all maltings employing power is ruled almost exclusively by economic considerations.

ANTISEPTICS.

The antiseptics used by maltsters are few and simple.

Common lime, bisulphite of lime, and salicylic acid are chiefly employed, while hydrochloric acid, chloride of lime, and permanganate of potash are used only very rarely.

Sulphur is sometimes used for bleaching purposes, and necessarily exerts such antiseptic influence as the manner of its use compels. Very few fuels are free from sulphur, so that almost invariably it comes into direct contact with drying malt in some form.

The sulphur found in coal or coke often exists in two states, partly as sulphuric acid combined with lime, which remains unaltered in the furnace, and partly as sulphur combined with iron, which is decomposed by heat, yielding the sulphurous acid gas, which exerts considerable antiseptic and bleaching influences upon the barley or malt with which it comes into contact.

Under ordinary circumstances mould in malt is readily and rapidly propagated. It is always desirable, for every reason, to prevent such propagation as far as possible. Proper selection of materials, combined with careful use, and the strictest cleanliness, are unavailing to eradicate mould. Powerful antiseptics, if used in moderation, exert but little appreciable deleterious influence upon either the growing corn or finished malt. Their influence upon low fungoid organisms is very great, and consequently it is desirable to use bisulphite of lime, or some similar compound, upon the growing floors, and in cisterns, prior to the commencement of the season, occasionally during the winter, but more frequently in the spring and early summer.

The recently accepted interpretation of the significance and effects of the practical development of the Germ Theory exercises great influence upon a maltster's use or disuse of any antiseptic. Many writers, notably Tyndall in this country, and Pasteur and others abroad, have investigated, with immense labour and patience, the phases of existence and influences of many of the minute lower organisms. The result of their work has been to throw much light upon several difficulties which had been mysterious and incomprehensible to practical maltsters. Far from the truth as we may yet be, this theory has, nevertheless, already seemingly elucidated many abstruse problems, and has, amongst other benefits, furnished us with practical and sound reasons for the adoption of such chemicals as enable us to destroy or vitiate the minute organisms or their germs, which exert influences of a damaging or dangerous character if permitted to develop.

Everyone now believes, and probably rightly, that putrefaction is accompanied with, and usually accomplished by, numerous organisms rarely acting entirely alone, but most usually accomplishing some distinct purpose in concert with each other. This is supposed to be proved by the fact so commonly observed that any substance which under ordinary conditions easily putrefies, may be preserved for long periods free from decomposition by placing it in any position absolutely inimical to vegetable or animal life, or, on the other hand, it may be placed in every condition favourable to the development of life, and yet be kept intact if care be taken to prevent the access of any individual or germ. For instance, meat travels through the tropics from Australia to England, if simply kept constantly at a temperature lower than 32°, or the same meat may be kept at any common atmospheric temperature, if the simple precaution be taken of sterilising the air in which it is immersed. Free access of air properly deprived of every spore and germ may, however, exert influences of an undesirable character other than ordinary putrefaction.

The maltster must necessarily give germinating corn free and ample supplies of air, in such a form that its total sterilisation is very difficult. Were it otherwise, the corn has invariably adhering to it many germs of an undesirable character, and the conditions of germination necessarily favour their rapid development and reproduction. To destroy these, comparatively few things are available, for chloride of lime, permanganate of potash, and other powerful antiseptics of that class have obvious disadvantages fatal to their use. Little real objection can be urged against bisulphite of lime, and its common uses are as follows.

With sound, sweet corn it is in most cases unnecessary to add bisulphite of lime to the steep-liquor. Should any tendency to mould manifest itself, it can easily be added when sprinkling is performed.

Jericka strongly recommends sprinkling of all barley- and malt- storage bins with bisulphite of lime immediately they are emptied, and again prior to use. The plan is a very good one. Scrub the floors well with water to which ten per cent. of strong good bisulphite has been added. Only in rare cases, and upon very bad floors, is a stronger solution necessary.

With weak, defective, inferior, or badly-conditioned corn, a suitable and proportionate quantity of bisulphite is beneficial, both in cistern and upon floors.

The quantities of bisulphite of lime employed to advantage are as follows :—

In steeping cistern, from a quarter to half-a-pint per quarter steeped ; sometimes less.

In sprinkling liquor, half-a-pint per can of four gallons.

Prior to use, floors may be sprinkled with bisulphite of lime and water, mixed in equal proportions.

Every time the cistern is emptied it should be carefully washed with water which has an addition of ten per cent. of bisulphite of lime.

Quicklime is used upon floors and walls in several ways.

Walls and ceilings are whitewashed or limewhited by placing several clear free lumps of freshly-burned lime in a pail of water and applying it with an ordinary whitewasher's brush when still hot from the heat naturally produced by the hydration of the caustic lime.

Limewhite applied to iron cisterns or tanks is a very excellent thing to preserve the water from putrefaction.

Finely-powdered chalk is sometimes sprinkled upon the surface of barley in the cistern in places where the steep-liquor is soft or full of organic matter, with the object of lessening its extractiveness and reducing acidity.

WATER.

Maltsters ordinarily pay little attention to the water used in the cistern either as to its temperature or quality. That which is obtained at the least expenditure of capital and energy is that which is commonly used. Hence we find water from all usual sources employed, with the exception, of course, of decidedly brackish and salt-water.

As water exerts a very distinct influence upon the characteristics of beer and the colour of bread, so also has it considerable power to modify the colour and quality of malt. A place which has a high character for the malt made in it has generally, one would suppose, water which is suitable for malting. That this is not the case is easily accounted for by the fact that malt, as made hitherto, varies so greatly from what it should be, that the comparatively minor influence of the water used has almost escaped notice.

The majority of the writers upon malting agree in preferring a hard saline water for steeping, and on the whole such a conclusion is best for several reasons, the chief of which is that hard water dissolves and consequently removes less of the soluble nitrogenous substances of barley than soft water. This same reason accounts to a considerable extent for the fact, that soft steeping liquor, if seldom changed, becomes much more putrescent than hard water retained with the same barleys for a similar period in cistern. Analyses of the steep-liquors show that a soft water dissolves a larger percentage of the more soluble nitrogenous matters than hard, and also washes out more phosphoric acid, and the resulting phosphate of potassium is favourable to the development of mould. (See also Chap. XIX.)

Water containing organic matter is decidedly objectionable for steeping purposes. This is evidenced by the greater readiness it possesses to decompose and become unpleasant. Such contaminated water is very generally soft, being obtained from rivers, &c., and develops the evil just spoken of as the usual outcome of soft water. Soluble phosphates are washed from the barley, and favour the development of low fungoid growths to such an extent that very frequently the flavour of the malt is much affected and spoiled.

Soft water will remove as much soluble matter from barley as two per cent. of its weight; hard water 0·4 to one per cent. As such percentage of weight signifies a larger reduction in the total extractive matter obtained by brewers from malt, it is manifest that, apart from the evils already spoken of, the value of malt is diminished to an appreciable extent by soft extractive waters, even if uncontaminated. Some continental chemists have detected in steep-water not only the substances already named, but sugar, dextrine, and alcohol, succinic and other acids, &c.; thus loss necessarily occurs from steeping in any water, but the harder the water the less deleterious is its influence.

By steeping in soft-water barley containing comparatively little nitrogen, we get inferior malt to that from the same barley if steeped in hard or saline water. It is therefore advisable to add a quantity of salt to the steep-liquor when barleys low in albuminoids are steeped.

The following analyses of steep-water possess considerable interest.

I. [*]

	Before steeping.	After steeping.
Organic matter..	2·79 grs. per gallon	265·05 grs. per gallon.
Mineral matter..	26·30 grs. per gallon	155·70 grs. per gallon.
	29·09 grs. per gallon	420·75 grs. per gallon.

II. [†]

Barley.	Saal.	Bohemian.	Hungarian.
Organic matter..	70·295	79·185	106·482
Inorganic matter	70·417	82·254	102·736
Total grains per gallon..	140·712	161·449	209·218

This important matter is more fully dealt with in Chap. X., under the head of "Bye-products."

Free use of water in the malthouse is absolutely essential, not only in cistern, but for the purpose of cleanliness upon floors. A growing floor of any material, even metal, benefits by free and frequent flooding and scrubbing. All barley is improved by washing, for even the brightest and best has invariably clinging to it dust, dirt, and organic matters, which are baneful in action unless removed.

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[*] Sir J. B. Lawes. Report on Malt as Food for Stock. [1866].

[†] Behrend and Stuebcke. *Wochenschrift für Bierbrauerei*, 1884. [See also p. 182.]

Light (*see also* Chap. XIX., *Germination*).

Although light cannot be called a material in maltmaking, it is convenient to class it with the materials and consider its influences upon germination, which is the process of most importance in maltmaking.

Light has long been supposed capable of exerting a deleterious influence upon seeds in the earlier stages of growth. The fact that nearly all seeds grow better if covered with earth sufficiently deep to exclude light is quite sufficient to favour such a theory.

At various times many experiments have been made to determine the differences of development of the same seeds with all other conditions remaining the same, but with variations of light. These have been undertaken by several observers, notably Professor R. Hunt, Dr. Gladstone, Professor Daubeny, M. Planchon, and others. Many malthouses are to be found having the air passages open and no windows glazed. Others have all windows glazed with blue glass. Very few have yellow glass* or canvas.

Professor Daubeny† shows that seeds (including *Hordeum sativum*) produce rootlets and plumules in the following manner.

South Aspect.			North Aspect.	
Percentage of Radicles.	Percentage of Plumules.	Coloured Light Admitted.	Percentage of Radicles.	Percentage of Plumules.
66·6	38·3	Violet	56·5	45·5
63·9	38·3	Green	75·4	31·8
60·0	17·4	Kept dark	68·1	32·0
52·1	37·6	Cobalt Blue	70·1	24·6
46·6	24·6	Amber	63·9	24·6
42·0	10·1	Ruby	—	—
33·3	7·2	Orange	—	—

Many tables of experiments are given, and Professor Daubeny concludes that :—

"Upon the whole . . . light has very little to do with germination, and although the popular opinion may be well founded, viz., that the process goes on best in the dark, as maltsters generally believe, still, the light which interferes with the success of the operation, acts chiefly by producing such a degree of dryness as is unfavourable to the sprouting of the seed, and not by itself interfering directly with the result."

A series of very carefully-conducted experiments made by me during the spring of 1884 do not quite confirm this, nor do they support Thausing's‡ assertion that "the radicles are developed more strongly when light is admitted." The chief cause of this difference of opinion rests probably in the undiscovered influences of light upon mould, bacteria, and other low organisms, a field of investigation deserving much careful study and experiment, but of which our knowledge is too limited at present to warrant the expression of very definite conclusions.

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* This probably survives the application of W. R. Taylor's patent, No. 3,087, December 1, 1865, in which the use of yellow media is protected.

† *Rep. Brit. Assoc.* 1855, pp. 56-60.

‡ Preparation of Malt and Fabrication of Beer, American edition, p. 286. This opinion does not appear in the 2nd German edition [1882], where it is stated (p. 280), that the rootlets are stronger in the dark. See also Richter, *Sits. K. Ak. Wiss. Wien*, bd. lxxx. p. 16 [1880].

The following schedule of one experiment will suffice to indicate the manner in which the tests were conducted by Mr. Vincent and myself.

The apparatus used were the Coldewe germinating trays and a number of boxes fitted with blue glass, or with louvred sides, enabling entire control of the light to be accomplished, with no interference with air, heat, &c.

In this experiment one sample of barley was used—a sound dry Norfolk barley of fair quality.

Each tray received eight ounces of clean dry sand, and they were all wetted simultaneously.

Result of placing 600 *grains of barley in wet sand in six varied lights, and* 100 *grains in water, in the Brewing-room, Park Street, London, S.E.*

I.—Dark Box in South Window.

Date and Time.	Temperature.	No. Grown.	No. of Acrospires.	Longest Root in Inches.	Longest Acrospire in Inches.	Remarks.
April, 1884.	Degs.					
13th, noon	68	46	—	—	—	
14th, noon	68	83	—	0·5	—	
15th, 11 a.m...	72	93	—	0·75	—	Roots very irregular, bushy and mouldy: one corn with six radicles.
16th.	—	—	—	—	—	Sunday.
17th, 11 a.m...	70	96	8	1·75	0·375	Roots irregular, not very mouldy; average, 1 inch.
18th, noon ..	73	97	36	2·25	0·75	Roots irregular, mouldy; sand wetted.
19th, noon	68	97	65	2·5	1·125	Roots more regular.
20th, 11 a.m...	65	97	88	2·5	2·25	
21st, 11 a.m. ..	61	98	96	3·0	3·25	Roots very weak and irregular; many drops of yellowish matter descending roots.
26th, 11 a.m...	62	100	100	8·0	7·25	Roots weak; average, 2 inches or less; only six over 3 inches. Acrospires weak; average, 2 to 3 inches; six only over 4 inches.

Has grown, all through, much better than Nos. II., IV., or V.

II.—Open, on Counter below South Window.

13th, noon	68	37	—	—	—	
14th, noon	68	84	—	0·375	—	
15th, 11 a.m. ..	72	91	—	0·875	—	Roots irregular and mouldy.
16th	—	—	—	—	—	Sunday.
17th, 11 a.m...	70	94	—	1·75	—	Roots very irregular, mouldy.
18th, 11 a.m...	73	95	4	1·75	—	Roots very weak and irregular; sand wetted.
19th, noon	68	95	10	1·75	0·75	Roots weak.

II.—Open, on Counter below South Window—(*continued*).

Date and Time.	Temperature.	No. Grown.	No. of Acrospires.	Longest Root in Inches.	Longest Acrospire in Inches.	Remarks.
April, 1884.	Degs.					
20th, 11 a.m. .	65	95	21	1·75	0·875	Roots weak; sand wetted.
21st, 11 a.m. ..	61	96	24	1·75	1·125	Roots very weak; acrospires very irregular.
26th, 11 a.m. ..	62	100	57	1·75	2·25	Roots very weak and bad; acrospires mostly just out; only four over 1 inch.

Proves the evil of direct sun rays.

III.—In Blue Box on South Window.

13th, noon	68	38	—	—	—	
14th, noon	68	74	—	—	—	Behind Nos. I and II.
15th, 11 a.m. ..	74 (in sun.)	86	—	0·75	—	Roots irregular.
16th	—	—	—	—	—	Sunday.
17th, 11 a.m. ..	70	88	1	1·625	—	Roots irregular; free from mould.
18th, noon	75	90	24	2·0	0·75	Roots irregular, very weak; heat too great; sand wetted.
19th, noon	68	90	40	2·25	1·0	Roots more regular.
20th, 11 a.m. ..	66	90	71	2·375	1·625	Roots regular.
21st, 11 a.m. ..	62	90	77	2·375	2·375	Few drops on roots as No. I.; acrospires healthy and regular.
26th, 11 a.m. ..	62	90	90	4·5	6·0	Much matter and mould on roots; average, 2·5 inches; acrospires very healthy and good; average, 3-4 inches.

Singular number of dead corns.

IV.—Open, on Sill of East Window.

13th, noon	68	43	—	—	—	
14th, noon	63	83	—	—	—	Backward.
15th, 11 a.m. ..	66	90	—	0 5	—	Roots fairly regular.
16th	—	—	—	—	—	Sunday.
17th, 11 a.m. .	66	90	—	1·375	—	Roots regular; rather mouldy.
18th, noon	68	94	6	2·0	—	Roots regular, but weak; sand wetted.
19th, noon	66	95	28	2·125	0·625	Roots very weak.
20th, 11 a.m.	63	96	67	2·125	1·0	Roots very weak; sand wetted.
21st, 11 a.m. ..	60	96	72	2·125	1·25	Roots very weak and queer; acrospires weak, but better than No. II.
26th, 11 a.m. ..	60	97	91	2·5	3·75	Roots very weak; average, 1·75; acrospires very weak and bad.

Confirms No. II. as to evil of much light.

V.—In Dark Box in East Window.

Date and Time.	Temperature.	No. Grown.	No. of Acrospires.	Longest Root in Inches.	Longest Acrospire in Inches.	Remarks.
April, 1884.	Degs.					
13th, noon	68	42	—	—	—	
14th, noon	63	84	—	—	—	Very backward.
15th, 11 a.m...	66	94	—	0·5	—	Roots regular.
16th	—	—	—	—	—	Sunday.
17th, 11 a.m...	66	96	—	1·125	—	Roots very mouldy and bad.
18th, noon	68	96	7	1·375	—	Roots very mouldy and weak; sand wetted.
19th, noon ..	66	96	25	1·375	1·0	Roots bad.
20th, 11 a.m...	63	96	71	2·0	1·5	Roots bad.
21st, 11 a.m. ..	60	96	72	2·0	2·0	Roots very weak.
26th, 11 a.m...	60	100	94	2·125	4·5	Two only just chitted; roots very weak and mouldy.

Similar generally to No. I., but more regular.

VI.—Open, in Back Office, Diffused Light Only.

13th, noon	56	—	—	—	—	
14th, noon	62	91	—	—	—	Three mouldy.
15th, 11 a.m. ..	61	98	—	0·25	—	Roots very regular.
16th	—	—	—	—	—	Sunday.
17th, 11 a.m...	60	99	—	0·75	—	Roots regular, but very mouldy; watered with 3 per cent. solution of bisulphite.
18th, noon	60	99	54	—	—	Mould gone, but roots very weak and discoloured; sand wetted.
19th, noon ...	61	99	76	0·75	—	Mould gone, roots more bushy.
20th, 11 a.m. .	58	99	99	0·875	0·875	Mould reappears; shortest acrospire, ·125 inch.
21st, 11 a.m. ..	54	99	99	1·25	1·25	Roots fair; acrospires all very regular and good.
26th, 11 a.m...	52	100	99	2·5	2·125	Roots very good.

All extremely regular, the *best* being from twelve very much stained and blackened kernels, the *only* bad-looking grains in the 700.

VII.—In Water in a Dark Cupboard.

13th, noon	69	
14th, noon	69	Water very milky.
15th, 11 a.m...	71	Very milky and putrid.
16th	—	Sunday.
17th, 11 a.m...	72	Very milky and putrid; no sign of chitting.
18th, noon .. .. · ..	75	Water very putrid and flocculent.
19th, noon	70	Very putrid.
20th, 11 a.m.	—	Horribly putrid.
21st, 11 a.m.	60	Taken out after 210 hours and put in flannel.
26th, 11 a.m... .. .	—	No sign of life.

The weather of the above days—March 13 to 26, 1884—was as follows: 13th, fine, sunny; 15th to 18th, like June; 19th and 20th, very fine, but cooler; 21st, fine, with cold wind; 26th, very cold.

The best (excepting in number grown) has been III. The most regular has been VI. The order of goodness is :—

1st,	VI.—	Number grown,	100
2nd,	III.—	,,	90
3rd,	I.—	,,	100
4th,	V.—	,,	100
5th,	IV.—	Number grown,	97
6th,	II.—	,,	100
7th,	VII.—	,,	—

Average growth of whole sample of 600 corns, 97·83 per cent.

Some of the conclusions of a purely practical character to be drawn from the results of these experiments are as follows :—

Heat is beneficial if regular and moderate. In every case those trays that were kept cool grew better than the same corn maintained at a higher temperature ; the number of corns that properly started growth in fifty hours was considerably greater, and all after-development was more favourable, excepting the greater abundance of mould. Bisulphite of lime effectually met this difficulty when properly used. Attention should be given to the fact that in every experiment some corns grew after a lapse of several days. In the majority of cases, corns commenced to grow *after twelve days.*

Air is apparently more important than heat, and exerts more influence than light, or the nature of light. Drowned corns—*i.e.*, those corns excluded from air—would not grow at all. Those kept in the dark did better in every case than those in the light. Those in the blue box succeeded best of all in every respect excepting that of number grown.

The broad general statement may be deduced from these experiments that the conditions surrounding corn in the malting have more to do with the character of the malt made than most maltsters admit. They show (what careful workers notice in practice) that abundance of air, coolness, and darkness are better for the right germination of corn than heat, light, and confinement, provided the undue development of mould be not occasioned by exclusion of light.

The amount of light and degree of heat best adapted to a maltster's needs have to be ruled by the nature of the corn worked. M. Planchon states that " Light and heat act in an identical manner on the absorbing power of seeds, at least on that which concerns the absorption of oxygen; they renew its activity, and this acceleratory influence augments as its power becomes intensified. Thus it cannot be doubted that light is favourable to germination, because it augments the absorption of oxygen.

" When the absorbing power of seed becomes weak, that is to say, at a low temperature, light ought to replace heat in a most useful manner. It can easily be understood that a very intense light acting with an elevated temperature renders the oxidation very active, and thus exercises an injurious influence on the life of the vegetable embryo. The acceleratory and favourable action of light on seeds seems to become stronger as the temperature becomes more elevated, and becomes injurious when it has attained a certain degree."

Practice and experiments do not confirm these conclusions.

CHAPTER VI.

MINOR MALT-PRODUCING GRAINS—MAIZE, OATS, RICE, RYE, WHEAT.

Maize :—
  Botanical definition. Character. History. Analyses of dhours. Values. Analyses of maize. Starch of maize.
Oats :—
  Botanical definition. Character. Analyses. Starch of oats.
Rice :—
  Botanical definition. Character. Starch. Analyses of rice and of its ash.
Rye :—
  Botanical definition. Habitat. Ergot. Analyses of rye.
Wheat :—
  Botanical definition. Species. Values. Starch of wheat. Wheat-malt. Analyses of wheat. Table of analyses of all minor malting grains.

THIS chapter treats of those materials constituting malt when manufactured, which are more rarely or sparingly used than barley. Every description of seed *can* be malted, should a very great latitude be permitted in the meaning of the verb to malt. Those seeds spoken of now, however, will be such as are recognised commercially, and used chiefly in the manufacture of beer.

Arranged alphabetically, the minor malt-producing corns are —maize, oats, rice, rye, and wheat.

MAIZE.

Maize, Indian corn,* Turkish wheat or kukurutz, is known to botanists as *Zea mais*. *Zea* is a genus of grasses belonging to the tribe *Phalarideæ*. The male flowers are in terminal racemes ; spikelets, two-flowered ; glumes, nearly equal, terminating in sharp points ; pales, two, wedge-shaped, fleshy, oblique and truncated ; stamens, three. The female flowers are axillary in the sheaths of the leaves. Several female flowers are grouped together ; one only of each group usually perfects its seed, but the abortive ones can be detected, and help to account for the number of valves which are to be found in conjunction with each seed.

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* The "mondamin" of the North American Indians, mentioned in Longfellow's Hiawatha.

"The external bracts serve to protect the whole cone of associated female flowers of the maize, which are therefore not provided for by the hardening of the valves of the corolla, as in *Phalaris*, &c.; these envelopes are therefore but imperfectly represented in the ears of maize; and it will be observed that where the seed is abortive they are developed more fully."[*]

Maize is largely cultivated throughout most of the warmer temperate regions of the globe, and probably ranks next to rice as the grain which affords nutriment to the largest number of human beings. It has many qualities to recommend it for culture where the climate is sufficiently warm to ripen the grain properly, growing as it does freely in very different kinds of soil, as well as under dissimilar states of moisture and dryness. The cinquantine variety takes but three months to ripen, and the six-weeks, as its name implies, but half of even that short time.

By reason of its pleasant-tasting oil and easy digestibility, maize forms a valuable food for man and beast, and where it is much eaten by men, diseases of the bladder, epilepsy, and phthisis are unknown. But where cheap, and, therefore, probably diseased, maize is used, pellagra is prevalent, unless the grain be dried in ovens previous to use. Diseased grains contain a reddish oil and a neutral alkaloid, and their exterior bears spores of *Penicillium*, *Aspergillus*, and similar fungoid organisms. (See under Rye, p. 60.)

For brewing and distilling purposes it is chiefly used in the state of raw grain, but requires special preliminary treatment to remove the germ, which contains a large amount of protein compounds, and the oil, sometimes reaching seven per cent., communicates flavours to the beer or spirits, that do not commend themselves to all palates.

Maize is now being malted both by the gelatinisation process, the germination or common system of malting, and it makes a very excellent description of patent or black malt, largely used in Ireland for colouring porter and stout.

It is the most recently introduced of the cereals, but its original habitat is not quite certain. The origin and native land of all the cereals remains obscure, although all, excepting maize, are supposed to be indigenous in the Eastern hemisphere, whilst maize is affirmed to be of American origin, and to have been unknown in the old world before the time of Columbus. This last assertion is disputed from the fact that travellers have found it in cultivation in various parts of Asia and Africa before any intercourse had arisen with white men, and because it is described in the "Nieuwe Herball," published 1578, as *Frumentum Turcicum vel Asiaticum.*[†]

[‡] For some time past Belgian distillers have been using a seed or kind of corn called dari, which resembles maize, for the production of alcohol, and it is also used to some extent in

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[*] R. A. C. AUSTEN, *Rep. Brit. Assoc.* for 1849, *Sections*, p. 68.

[†] A. W. BUCKLAND. Primitive Agriculture. *Rep. Brit. Assoc.* 1876, *Sections*, p. 164.

[‡] *Engineer*, July 21, 1882, vol. liv., p. 43.

Ireland. This grain is imported chiefly from Egypt and Syria, and its composition is as follows.:—

	Egyptian dari.	Syrian dari.
Water	10·05	9·97
Nitrogenous constituents	7·05	9·88
Fat	6·11	3·52
Extract free from nitrogen	74·20	72·22
Husk	0·97	1·63
Ash	1·62	2·18

This dari is the same as the *dhoura* from which the Nubians make a kind of beer called *bouza.*

However useful maize may be to a brewer as raw or gelatinised grain, or as black malt, it is at present impossible to find any satisfactory maize-malt (properly so called). The germination of maize is difficult in consequence of the construction and nature of the kernel and its tenderness when growing. It is in addition very liable to heat in transit, such heating very generally causing defective vegetative capacity, fatal to malting, but of less consequence to the corn if gelatinised or simply ground, as used by distillers.

The value of maize is determined by actual and comparative weight and freedom from injury. Few of the cereals vary more widely in the percentages of moisture present.

The following analyses sufficiently indicate the composition.

Payen found 14 per cent. water in maize, and the dried grain consisted of:—

		Truly.
Husk	5·9	5·074
Gluten	12·3	10·578
Starch	71·2	61·232
Sugar and gum	0·4	0·344
Fatty matter	9·0	7·740
Saline matter or ash	1·2	1·032
Water	—	14·000

The ash being:—

	*	†
Potassa	26·63	30·8
Soda	7·54	
Lime	1·59	1·3
Magnesia	15·44	17·0
Phosphoric acid	39·65	50·0
Sulphuric acid	5·54	—
Silica	2·09	0·8
Sesquioxide of iron	0·60	—
Loss	0·92	0·1

A very full account of the chemical composition of the different parts of the maize plant at various stages of growth is given by Hornberger and von Raumer in the *Landwirthlicher Jahrbuch* for 1882, p. 359, and another by H. Leplay in the *Comptes Rendus*, 1882-83, t. xcv., pp. 1033, 1133; t. xcvi., p. 159.

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* Fromberg; grown in United States. † Letellier; grown at Bechelbroun.

Dr. Bauer[*] furnishes a table giving the values of five samples of two descriptions of American maize.

	Nitrogenous compounds.	Non-nitrogenous.[†]	Fat.	Ash.	Water.
White I.	8·4	67·42	4·32	1·47	9·11
,, II.	9·2	67·91	4·53	1·54	11·8
,, III.	8·7	69·52	4·62	1·59	10·4
Yellow I.	10·2	66·47	5·12	1·72	11·9
,, II.	9·5	64·21	4·98	1·64	12·2

The granules of starch in maize vary considerably, those from the harder portion of the berry differing in size and shape from those of the softer, or mealy part. They are compound and single.

OATS (*Avena sativa*).

"Tu . . . . silvestrem tenui Musam meditaris avenâ."[‡]

The genus *Avena* is distinguished by large membranaceous outer pales enclosing from two to three florets, each armed with an awn more or less twisted and bent.

The wild oat, *A. fatua*, can in nine or ten generations be transformed into the potato and Tartarian varieties of the cultivated oat, gradually losing the hairs on the pales and increasing in plumpness of grain.

The oat is much lighter than barley, a bushel weighing about 36 lbs. to 38 lbs. on the average, good heavy samples running up to 44 lbs. It contains also much more cellulose and fat than barley. It is but little used in brewing, although it is easily and profitably malted, for though its nitrogenous constituents are in less proportion than those of barley, their character is such as to resist clarification of the resulting beer, unless used under favourable conditions of water.

Beer made from oats is, however, very pleasant to the palate, and has a soft-drinking roundness or fullness, much liked. Now that the duty is removed from malt, oats can be malted with economy, and they deserve much more extended use.

The growth of the acrospire is the same as in barley, and if grown freely the roots develope fully, to the advantage of the malt. The comparative cheapness of oats, shown by market quotations at per quarter, is capable of considerable modification by the following estimations by Pillitz and Muspratt.

				Albuminates				
Water.	Starch.	Dextrine.	Sugar.	Soluble.	Insoluble.	Cellulose.	Fat.	Ash.
13·6	46·78	1·25	0·32	2·3	10·36	16·21	4·2	3·6
	Carbonaceous matters.		Nitrogenous matter.					
14·0		11·99		61·5		4·1	5·5	3·0

RICE (*Oryza sativa*).

The inflorescence is in panicles; there are two glumes not exactly opposite; the outer pale is ribbed. The seeds grow on separate pedicels which spring from the main stalk, and each grain is usually terminated by an awn or beard resembling that of some kinds of wheat. It is a marsh plant, and can only be cultivated successfully when the ground can be inundated during a certain period of its growth; besides which it requires a temperature of 60° to 80° Fahr. to ripen; consequently its cultivation in Europe is limited, being chiefly confined to Lombardy.

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[*] *American Brewers' Journal*, 1881.

[†] Starch, dextrine, and sugar

[‡] Virgil, I. Eclogue 2.

Rice contains more starch and less gluten than any other grain, and is rapidly becoming largely used in brewing in Great Britain in both its raw and gelatinised state. It has been malted in Japan for ages, and is almost exclusively the grain used for beer-making in that country. (See chap. xii.)

Rice, as usually imported into Britain, is incapable of being made into malt by the common processes of germination, owing to the rough treatment it receives in removing the husk and outer skin or testa. As it is such a pure grain, and when gelatinised is so well adapted to produce a pure and satisfactory wort, it may perhaps be regarded as an unnecessary if not undesirable thing to attempt to malt rice at all.

The granules of starch in rice are single and compound. They vary largely in size from climate, soil, position, species, &c., &c.

The following analyses sufficiently indicate the general character of rice.

Name of Analyst.		Starch.	Gluten.	Fat.	Sugar and Gum.	Epidermis.	Ash.	Water.
Payen ...	(dry rice)	86·9	7·5	0·8	0·5	3·4	0·9	—
,, ...	,,	75·17	6·49	0·69	0·43	2·94	0·78	13·5
			Proteins.			Cellulose		
Wigner ...	Madras ...	77·68	6·3	1.11	0·87	0·56	1·02	12·46
,, ...	Raree ...	75·23	5·94	1·96	1·14	1·04	2·60	12·09
Atkinson ...	Banshiui ...	69·23	6·78	1·85	6·45	3·27	1·21	12·86
,, ...	Kazal ...	72·81	4·3	1·18	4·4	2·67	2·04	12·6

Bechilbroun has found the ash of rice and rice-husk to consist of:—

Ash of Rice.

	Grain.	Husk.
Potassa	18·48	1·60
Soda	10·67	1·58
Magnesia	11·69	1·96
Lime	1·27	1·01
Phosphoric acid	53·36	1·86
Sulphuric ,,	—	0·92
Silica	3·35	89·71
Sesquioxide of iron	0·45	0·54

Rice contains less fatty matter than any other grain, and, as with most cereals, the greater portion is found in the husk.

Rye (*Secale cereale*).

Rye is related to wheat, but is distinguished by its spiked inflorescence, which bears two-flowered spikelets, having a long-stalked rudiment of a third floret: the glumes are awlshaped. It is a highly nutritious cereal, largely used in the east of Europe as a food-grain, and in the production of alcohol. It appears to be a native of the Crimean mountains, and thrives best in dry regions, being subject in damp localities to ergotism.* It is a lighter grain than wheat, but heavier than most barley, a bushel weighing on an average 57 lbs. Except in Russia and some parts of Belgium, rye is not used in brewing, from its tendency to butyric fermentation and from the excess of protein-compounds, which prevents clarification.

The albuminoids of rye are less stable than those of other grain, putrefying to ptomopeptones if the grain or meal be left damp. This is evidenced by the evolution of trimethylamine when such meal is heated with alkali. The high diastatic power of the rye-proteins causes, in cases of unfavourable harvests, the conversion to glucose of a considerable quantity of the starch ; and in the presence of mildew, ergot, and similar ferments (common in rye, on account of the instability of its proteins), the glucose passes in part into lactic and butyric acids. Maize and oats approach rye in these respects, being liable to similar fermentative and putrefactive influences, which produce epidemics where the affected grain is extensively consumed as human food.

Rye, like wheat, develops the acrospire outside the cuticle, and as a consequence is difficult to germinate. It is rarely malted. The composition of the grain renders its use in beer undesirable. Its constituents are thus indicated by Muspratt :—

Water.	Ash.	Nitrogenous principles.	Carbonaceous matters.	Cellulose.	Fat.
16·6	1·9	9·0	67·7	3·0	2·0

And more fully by Pillitz :—

Water.	Ash.	Starch.	Dextrine.	Sugar.	Extractive matter.	Cellulose.	Fat.	Albuminates.	
								Soluble.	Insoluble.
13·85	1·45	56·41	4·97	1·87	3·61	3·93	2·17	3·33	9·11

WHEAT (*Triticum vulgare*).

Common wheat has solitary quadrangular imbricated spikes (ears), with four-flowered spikelets ; the valves ventricose, ovate, truncate, mucronate, and compressed under the apex, the nerve somewhat prominent. Cultivation has produced so vast a number of varieties of this leading cereal, that a mere enumeration of their names would take up a greater space than I wish to devote to this topic, the grain being but little used for brewing purposes.

The genus *Triticum* has been divided into *Cerealia* and *Agropyra*, that is, useful grain and grasses respectively, the couchgrass or twitch, *T. repens*, being an example—only too familiar to farmers—of the division *Agropyra*, whilst wheat and spelt, in their many varieties, are *Cerealia*.

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* Ergot is a disease in which the seeds of rye and other grasses are converted into a black, hornshaped spur, containing an organic principle which is used in medicine, and which, when occurring in pastures, gives rise to abortion of stock. Its occasional presence in rye-bread has been known to produce serious disorders (see bibliography).

The distinction of spring and winter wheat is arbitrary, as in two or three seasons either can be converted into the other. Certainly they do not merit the distinctive varietal names—*æstivum* and *hibernum*. The wheats are distinguished from the spelts by the grain of the former being readily detached from the husk, which in the spelts, as in oats and barley, is adherent to the grain.

Emmer (*Triticum amyleum*), spelt (*T. spelta*), and horse-spelt, or one-grained wheat (*T. monococcum*), are grown to a considerable extent in South Germany. Rev. Prof. Henslow[*] concludes that M. Fabre's original statement that *Ægilops ovata* was the origin of the domestic wheat was not altogether without foundation, though he had not succeeded in obtaining the characters of wheat from *Æ. squarrosa*.

Theodore de Saussure, in his "Recherches Chimiques sur la Végétation" (8vo, Paris, 1804), gives the analyses of the ash of the grain and of the straw of wheat, barley, &c., as follows:—

	WHEAT.		BARLEY.	
	Grain.	Straw.	Grain.	Straw.
Potash (carbonate)	15·0	12·5	18·0	16·0
Phosphate of potash	32·0	5·0	9·2	—
Muriate of potash	0·16	3·0	0·25	3·5
Sulphate of potash	trace	2·0	0·5	0·5
Earthy phosphates	44·5	6·2	32·5	7·75
Silica	0·5	61·5	35·5	57·0
Metallic oxides	0·25	1·0	0·25	0·5
Loss	7·59	7·8	2·8	2·25
Earthy carbonates	0·0	1·0	—	12·5

Wheat is the chief cereal cultivated in Europe and America, and from the great attention which it has received from agriculturists, it has developed into a larger series of varieties than any other alimentary grain. The varieties differ in colour, in the presence or absence of awns, in dimensions of the grain, and of the entire plant. The alimentary value of wheat is due largely to its high percentage of starch, and it also contains a large proportion of gluten.[†] The latter substance produces the vitreous appearance of the grains of the red wheats, whilst the mealy character of the yellow wheats is due to their consisting so largely of starch.

The average density of wheat is over 1·4, and is higher in proportion to its amount of gluten. Of fatty matter it contains from 2 to 3 per cent., and about 2 per cent. of ash, but this varies with soil, manures, &c.

The starch of wheat is less easily convertible than that of other grain, and it is comparatively rarely used in brewing, partly on this account, but chiefly from its high price, the

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[*] *Rep. Brit. Assoc.* for 1856, *Sections*, p. 87 (see bibliography).

[†] STUMPF states (*Centr. Agrik.-Chem.* 1882, p. 786) that the best German and American wheats contain 24 per cent. of gluten; South Russian, 45; Californian and Australian, 23 to 24. The Russian is mixed with starchy English wheat, and sold under the name of mixed Dantzic wheat.

In 100 Parts by Weight.	Moisture.	Starch.	Dextrine.	Sugar.	Albuminates.		Cellulose.	Fat and Oils.	Ash.	Extractive Matter.	Analyst.
					Soluble.	Insoluble					
Barley	13·88	54·07	1·7	2·43	1·77	12·43	7·76	2·66	2·33	1·50	Pillitz.
Barley-Malt	7·51	48·77	8·82	5·48	1·48	10·71	14·37		2·50	—	Christopher.
Maize	13·89	62·69	0·76	1·38	1·87	8·63	4·19	4·36	1·48	1·43	Pillitz.
Maize, Germless	13·16	73·92	3·00	—	—	7·35	0·8	1·29	0·48	—	Wigner.
Oats	13·61	46·78	1·25	0·32	2·30	10·36	16·21	4·20	3·56	1·42	Pillitz.
Rice, Cleaned	12·51	74·88	1·11	—	0·41	8·78	0·76	0·78	0·84	0·11	Do.
Rice, Cleaned	12·20	79·16		·59	6·30		·18	·67	·90	—	Wigner.
Rice, Common (Japan) ..	11·96	74·69	3·22		4·79		2·98	·90	1·46	—	Atkinson.
Rice, Gelatinised	9·63	77·20	2·96	—	·13	8·62	·33	·43	·70	0·1	Aug. Voelcker.
Wheat	12·41	62·82	2·46	0·95	0·98	10·08	3·4	1·97	2·61	2·32	Pillitz.
Wheat Spelt, without husk	13·10	61·72	2·12	1·06	2·27	9·03	2·92	2·53	1·91	2·59	Do.
Rye	13·85	56·41	4·97	1·87	3·33	9·11	3·93	2·17	1·45	3·61	Do.

difficulty of malting a huskless grain, and of mashing the resulting malt, and the excess of protein-compounds complicating the subsequent processes. The red wheats are, of course, more objectionable on the last-mentioned ground than the yellow. Wheat is, however, used for brewing in some parts of Germany and Belgium in the manufacture of Weiss beer, and also in Britain during those seasons when it is relatively cheaper than barley, or for making full-bodied and stock beers.

Wheat has never malted properly, owing to its natural defects of excess of gluten and tenderness of acrospire, which not only grows upon the exterior of the grain, but appears almost immediately after the roots, and at the same end of the corn. Many attempts have been made to malt it with oats, barley, or other protecting grain, but great care has been needed, and the result has not always been satisfactory even to the maltster, and still less to the brewer.

The starch of wheat very much resembles that of rye and barley. Wiesner asserts that the granules of these three grains all possess the same specific character, and can always be readily identified from all other starch granules. All large granules are lentiform, and small ones globular or polyhedral.

Déhérain and Meyer give, in the Annales Agronomiques for 1882, pp. 23—43, detailed tables of the composition of various parts of the wheat-plant at different stages of its growth.

The analyses on p. 62 show fairly clearly the values of all the preceding grains, and also of barley, in parts per hundred by weight.

CHAPTER VII.

BARLEY.

"Let husky wheat the haughs adorn,
And aits set up their awnie horn,
And peas and beans at e'en or morn
Perfume the plain.
Leeze me on thee, John Barleycorn,
Thou king of grain!"
BURNS.

Barley:—
History. Statistics of Cultivation in Great Britain. Botanical Definition. Common and Specific Names of Sixty-three Varieties. Brief Description of Mensury, Escurgeon, Bigg, Annat, and Chevalier Barleys. General Structure of Barley. Foreign Barley. Cultivation, Soil, Climate, Sowing. Manures—their Influence and Effect. Soils, Rotation, Harvesting, Climature.

FOR countless generations barley has been esteemed the grain best adapted to brewers' use when malted, from the character of the beer it produces. As it is also able to bear the process of malting with less injury than any other grain, seed, or fruit, it has, consequently, been used almost universally for making malt.

Tradition states that barley was the first cereal cultivated by man, and it is quite probable that in this case, as in so many others, traditional belief is based upon fact. That early and primitive races cultivated barley is proved by the abundance of its remains constantly found in the Swiss lake dwellings and elsewhere, and the earliest classical writers speak of it. So lost in the mist of the past is its origin that it is now fruitless to attempt to trace it. India, Tartary, Egypt, Siberia, and Scotland all claim to have originally produced it.*

The chief purpose for which barley is used is to make malt for brewing and distilling. It is rarely made into bread, but in a variety of ways is used occasionally as an article of human diet. All the inferior grades are used freely for pig-, cattle-, and poultry-feeding, and its medicinal virtues for fevers or inflammation are still occasionally put into requisition.†

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* Cunobelin, an early British king, stamped the reverse of his coins with a short barley-ear in bold relief.

† In reading various works on malting, a highflown and jaw-cracking description of the medicinal virtues of barley is frequently encountered. It is difficult to find the originator. It apparently gradually evolved from the opinions of Com-

Barley belongs to the genus *Hordeum* of Linnæus, several species of which have, by cultivation, been transformed into the large number of varieties now in use.

Hordeum is a genus of the order *Gramineæ*, of which wheat, rice, &c., are allied genera.

Its distinctive generic characters are the bivalved calyces with single flowers, arranged in triplets on the axis of the ear. In rye the flowers are double, whilst in wheat there is but one calyx, with from three to five flowers, on each tooth of the axis.

The full generic characters of *Hordeum* are as follows :—

Flowers glumed, hermaphrodite, on an ear which is generally simple, and formed of sessile, ventricose spikelets, closely disposed on an alternately toothed axis, three spikelets on each tooth. The spikelets bear single flowers, consisting of (1) involucre, with six linear acuminate, distant folioles disposed in pairs; (2) a bivalved corolla, the exterior valve oval, ventricose, acuminate, ending in a long beard, the interior valve smaller, lanceolate, smooth and without beard; (3) three stamens, with capillary filaments shorter than the corolla, ending in oblong anthers ; (4) ovary superior, turbinate, surmounted by two hairy styles : fruit enclosed in the indehiscent corolla, an oblong, ventricose, fusiform grain, sulcate on one side.

The principal species of *Hordeum* are—

H. vulgare
H. distichon } Common Barley.
H. coeleste
H. hexastichon (Bere, Bigg, or Escurgeon).
H. polystichon (Six-rowed barley).
H. zeocriton (Pyramidal Russian barley).

Hordeum vulgare is thus defined by Linné :—

"Hordeum flosculis omnibus hermaphroditis aristatis : ordinibus duobus erectioribus." (Syst. Plant. i. 235.) It is probably a native of Russia.[*]

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brune, Champion, and others. In its finite, crystalline form it occurs in Levesque, Muspratt, &c., and no future work on malting can be complete without it; for the influence exerted by malting on such a fearful compound must be considerable. "The medicinal qualities are, according to a celebrated physician, cooling and "drying in the first degree; they are gently repercussive, abstersive, diuretic, and "anodyne, appropriated to the lungs and reins" ("veins" by Muspratt, p. 236), "and galactogenetic. All barleys have the same qualities" (Levesque, p. 8). Barley has got better since then.

[*] Prof. Heer, in his account of the plants of the Lake Dwellings of Switzerland Zurich (1866), says:—"Probably the small six-rowed barley of the lake dwellings "is the original form from which the four-rowed barley has descended. The axes "of the ears have become longer by cultivation, the spikelets are pushed further "asunder, and therefore the longitudinal rows lie one over the other. We thus "find only four rows on the ears, and the form becomes what is known as common "barley, *Hordeum vulgare*. But there was also a change in another direction. In "the side florets the pistils do not come to perfection, and consequently only the "middle grains are productive; thus we get only two rows of grains, which "consequently become larger; and so, by the lengthening of the axes of the ears, "we get the two-rowed barley, *Hordeum distichon*, but by the shorter axes, the rice "barley, *Hordeum zeocriton*. I consider, however, all these forms of barley only as "varieties of one species (*Hordeum hexastichon*); in fact, they sometimes exhibit a "transition from one to another."

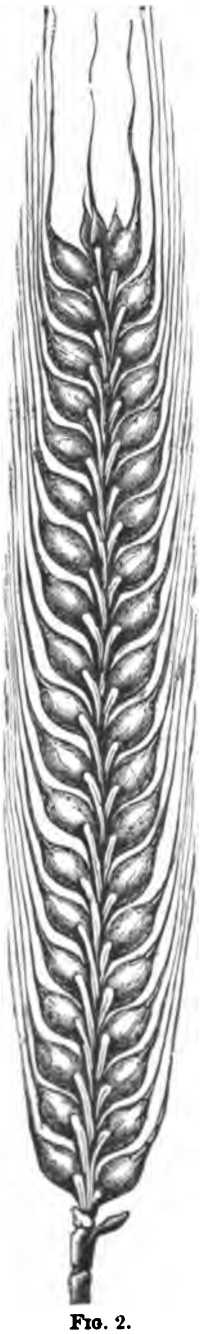

FIG. 2.
EAR OF BARLEY.

This species is the common barley cultivated throughout both temperate zones. It grows to a height of two or three feet, with a straight, smooth fluted straw. The leaves are long, pointed, about three-fourths of an inch wide, rough on both surfaces, except at the base, where they clasp the stem; they are of a clear green, with a white nervure along the edge. A brown tinge marks a slight contraction of the stem above each joint.

The flowers form an ear about three inches in length, with very long awns extending from the exterior valve of the corolla. The awns are finely barbed on both sides, and when dry are very brittle, so that any attempt by a bird to extract a shed grain from a crevice by the awn must fail, on account of the barbs holding and the awn breaking.

The folioles of the involucre are also bearded, but only by short hair-like processes. The ear is nearly square in section, but a little flattened. The grains are in three rows on each side, the outer ones standing out obliquely from the stem, the central row erect. The variety *β coeleste* has its seeds detached from their envelope.

"Hordeum distichon.—Hordeum flosculis "lateralibus masculis muticis seminibus "angularibus intricatis, distichis." Linné, Syst. Plant. i. 236. Probably a native of Samara, Asiatic Russia.

The spikelets are in two rows, composed of fertile flowers, the very long awns being furnished with short sharp teeth on both edges. The grain is imbricated, the angles of the husk set with very short stiff hairs. Between the rows of fertile flowers is a sterile row without stamens or beards. As in *H. vulgare*, there is a variety *H. nudum*, the seeds of which are detached from the husk.

The *H. gymnostichon* of some authors appears to be the naked variety of *H. vulgare* and *H. distichon*, which again some affirm to be but one species modified by cultivation.

Hordeum hexastichon is described by Linné as "Hordeum flosculis omnibus hermaphroditis aristatis: seminibus sexsariam positis." (Syst. Plant. i. 236.)

The flowers are in six rows, all equally separated from the stem, the ears are shorter and more compact than those of *H. vulgare*, but this may be the effect of cultivation.

" Hordeum zeocriton.—Hordeum flosculis lateralibus masculis muticis, seminibus angularibus patentibus corticatis." Linné (" Syst. Plant.," i. 236).

This grows to a greater height than the foregoing species; its leaves are glossy, very slightly rough, and not more than half an inch wide; the ear very short and pyramidal in form, with the awns spread like a fan. The hermaphrodite flowers have big stiff awns; the male flowers, set close to the stem, are beardless.

Appended is a list of the more prominent varieties in alphabetical order, for the greater part having the specific determinations. Perhaps the various common names by which barley is known in English books is not entirely uninteresting. This list could be greatly added to, if purely provincial and local designations were admitted. All the following terms are freely used by writers, apparently marking well-known varieties :—

Common Name.	Specific Name.
American barley.	—
Annat barley.	Hordeum distichon.
Battledore barley.	H. zeocriton.
Bearded barley.	H. distichon.
Beardless barley.	H. distichon.
Bere.	H. hexastichon.
Berkshire barley.	H. vulgare.
Bigg or four-rowed barley.	H. hexastichon.
Brewers' Delight barley.	—
Chevalier barley.	H. distichon.
Cheyne barley.	H. distichon.
Coffee barley.	H. distichon.
Common Long-ear barley.	H. vulgare.
Common winter barley.	H. vulgare hybernum.
Dunlop barley.	H. vulgare.
Early English barley.	H. vulgare.
Early ripe barley.	H. vulgare.
Egyptian barley.	—
Escurgeon.	H. hexastichon.
Fan barley.	H. distichon.
Fluckwheat barley.	—
German barley.	—
German rice barley.	H. zeocriton.
Golden drop barley.	—
Golden melon barley.	—
Heaven barley.	H. vulgare nudum, or cœleste.
Himalaya barley.	H. distichon.
Hotspur barley.	—
Italian four-rowed naked barley	—
Jerusalem barley.	H. vulgare nudum, or cœleste.
Mammoth barley.	H. hexastichon.
Mensury barley.	H. polystichon.

Common Name.	Specific Name.
Moldavian barley.	—
Naked barley.	H. vulgare nudum.
Noble barley.	—
Norfolk Short-neck barley.	—
Nottingham Long-ear barley.	—
Peacock barley.	—
Pearl barley.	—
Pomeranian barley.	—
Potter's barley.	—
Pyramidal Russian barley.	H. zeocriton.
Rathripe barley.	H. vulgare.
Rettema barley.	H. vulgare hybernum.
Rice barley.	H. distichon zeocriton.
Sand barley.	H. vulgare.
Siberian barley.	H. cœleste.
Soot barley.	H. vulgare hybernum.
Spoon barley.	H. trifurcatum.
Sprat barley.	H. zeocriton.
Square barley.	H. hexastichon.
Stirling barley.	—
Stock barley.	H. hexastichon.
Summer barley.	H. vulgare æstivum.
Thanet barley.	—
Turkish pfara barley.	H. zeocriton.
Two-rowed Battledore barley.	H. distichon.
Two-rowed Black barley.	H. distichon.
Two-rowed Sprat barley.	H. distichon.
Victoria bere.	H. hexastichon.
Winter barley.	H. hexastichon.
Zealand barley.	—
—	H. distichon densum (Swiss).

The blanks in either list are names I have been unable to verify.

Mensury. This is described as "a new variety likely to " become popular (in United States and Canada). It is six- " rowed, and was sent out by the department of Agriculture " five or six years ago. It originated in Canada. It has long " heavy heads, which hang down when filling, but its straw is " so strong that it does not fall down even on the richest land. " It has been tested for malting, and is superior for that " purpose. It ripens a little later than the common six-rowed, " and is easily distinguished from it when growing by a slightly " reddish tinge to the beard when the head appears."*

Escurgeon is a grain very little known in Britain at present, but which malts well in France, and is capable of yielding very satisfactory results to the brewer.

Chevalier barley is probably the most widely distributed and best known variety. It originated from the careful cultivation and selection of the Rev. J. Chevalier, Rector of Stonham,

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* *The German and American Brewers' Journal*, vol. vi. No. 12, p. 412 [1882].

Suffolk. It now grows most successfully in every country of Northern Europe, America, Australia, New Zealand, and even Chili. It produces heavy crops of extremely friable grain, distinguished by their almost transparent husk, high percentage of starch, evenness and plumpness of kernel, and great weight. All the best qualities of every class of barley seem combined in this one variety, excepting that it is not awnless.

Bere and bigg, of which there are numerous varieties, are useful for cultivation in high latitudes, in consequence of the short time they require to mature, and because they will properly ripen with very little sun. They stand handling in shock better than other barley. Their coarse, harsh skin and hard, unkindly grain always cause them to be disliked, if better barleys can be bought. Bigg rarely weighs more than 50 or 51 lbs. per imperial bushel, and was considered to be so much inferior to barley for malting, that, for the last seventy years in which the Malt Tax was levied, the duty on barley was 31 per cent. higher than that upon bigg. The Victoria bere is a new variety, that produces very heavy crops, and is nearly equal to good barley. Annat barley was first cultivated in the Carse of Gowrie. It much resembles Chevalier, is usually strongly rooted, and possesses abundance of straw over three feet long. It is a yellower variety, not quite so plump as good Chevalier. As it ripens more readily, and gives a higher yield per acre, it is much liked by farmers.

It is needless to describe at length the characteristics of the sixty-three varieties included in the above list.

Formerly the barley most approved by maltsters was called the Rath or Early Ripe, in consequence of its ripening two or three weeks before the common sorts. As it did not equal the Chevalier, it has to a large extent been replaced by the latter, and is now little grown. It was comparatively a plump, thin-skinned barley, but as on these points better sorts are now cultivated, it has passed from the general knowledge of maltsters.

In Raspail's Organic Chemistry, (see Bibliography) an elaborate description is given of the histology and chemistry of the grain.

Previous to fertilisation, the outer layer of the pericarp (husk) is thick and full of starch-granules. These changing to sugar and becoming soluble, pass into the perisperm and again become starch, constituting the grain. In germination this process is repeated, the starch of the grain becoming the sugar of the green malt, and, if left to grow, the starch of the resulting plant.

In the ripe grain of barley a long shield-like mark is seen at the base of the convex surface. This, the eye, or scar of separation from the parent flower, covers the germ, which is surrounded on all other sides by the white perisperm, the whole being enclosed in the brown and resinous pericarp. The perisperm consists of elongated hexagonal cells, ·0055 inch long by ·002 inch broad, containing starch, within glutinous membranes.

Moisture bursts these cells, and the decomposition of the gluten induces the change of the starch to sugar. The non-starchy matter of the pericarp changes during the ripening of the grain to a resin, protecting the bulk of the starch from the access of moisture. In the region of the hilum, near the embryo, this resin is absent, admitting moisture to the germ, and thence to the cotyledon on which it has to feed. Otherwise, the germ might be starved by the premature solution and diffusion through the pericarp of its intended nourishment.

The process of germination is accompanied by the formation of a trace of acetic acid, which attacks the glutinous membranes of the starch cells. The germ consists of a fleshy triangular cotyledon, the microscopic examination of which, even before germination, shows the structure of the stem and root of the future plant.

The composition of the entire grain remains problematical in the face of widely-differing results of analyses. The discrepancies are doubtless largely due to differences of the samples examined; but an important element of error lies in the liability to rapid change in the process of analysis.

" Of the many varieties of cultivated barley, those known as " distichous or two-rowed barley are those more commonly " cultivated, for in them the seed is tolerably uniform in size, " and so a better sample is produced, and we believe that it is " even more productive than the six-rowed form. This latter, " however, is frequently attempted to be employed in Germany " and America; but as the lateral florets are seldom so plump " as the central one, a very uneven sample is the result. This " is one of the causes of the greater coarseness of the varieties " of the six-rowed barley when compared with the two-rowed— " a fact perhaps more observable in the black variety than in " any other. In this group we must notice a naked six-rowed " variety, the grain of which separates from the chaff-scales " after the manner of wheat, the difference being that in " ordinary barley we have the grain and the chaff-scales, which " adhere, and form what is usually called the skin of the barley, " which is described as coarse or fine, according to its degree " of thickness; whilst in the naked barley we have the grain " *minus* the chaff-scales. This latter is not a good malting " kind, and therefore, though interesting from a botanical " point of view, is never likely to become extensively cultivated." (Professor J. Buckman.*)

Originally, in the United Kingdom, malt for brewing was made from home-grown barley only. Latterly, very considerable quantities from other countries have been imported. France, Germany, Denmark, and the bordering countries first exported to us; Algeria, Egypt, Syria, Russia, Chili, California, and even New Zealand, followed suit. Finally, in 1882, India sent some barley, but it has not yet been sufficiently good to tempt any maltster.

Some of the colonial and foreign corn is far superior to our own in appearance. Some varieties, that are uninviting in appearance, prove of great value in the mash-tun. Take, for instance, Algerian or Chilian. This is long, lean, hungry-looking stuff, that will weigh as little as 34 lbs. per bushel; yet if thirty per cent. of it be properly ground, and added to medium quality English malt, the resulting wort is of an improved character, and the extract will amount to as much as 84 lbs. per quarter. The diastatic power of this sun-ripe malt is naturally far greater than the bulk of the barleys of the United Kingdom when malted.

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* LINDLEY and MOORE's Treasury of Botany, 1873, pp. 596, 597.

CULTIVATION OF BARLEY.

So great are the influences of cultivation over the character of barley, that careful consideration of a few of the more important points is necessary—indeed, no man who ignores them can become so good a maltster, as he would be, if he gave them due and careful consideration. The effects of soil, climate, manure, etc., must always prove considerable.

Cold clay land, which is stiff or tenacious, no matter how well drained it may be, can rarely grow really good malting barley.

Barley delights in a warm friable soil, such as the calcareous loams, etc., of Norfolk, and the districts having a chalk sub-soil, which are the best natural soils. Rich, loamy, or well-manured sandy—and other dry soils—are also capable of producing fine barleys when the season favours them, especially if lime be present in fair quantities. Should too much manure be present, or if from any cause considerable decomposition of organic matter be taking place, the corn has too strongly-developed skin and husk, and is apt to be deficient in starch. Such corn, if malted, is dangerous to the brewer from its excess of nitrogenous compounds. Experiments in many countries have demonstrated almost beyond doubt that the percentage of nitrogen taken up by any seed or plant, is ruled by the nature of the soil in which it has grown, and the amount of nitrogen contained in the soil.

Barley is usually rich in magnesia, and consequently grows better in a soil containing sufficient magnesia for the proper development of the grain. If barley be grown upon clay, then six seasons, at least, ought to elapse before it is again sown, unless a very considerable dressing of chalk and sand has been given. Barley thrives best if sown somewhat deeply. When the seed-corn is spread over a channel three inches wide, it produces more and stronger straw, larger ears, and plumper, heavier corn, of better colour than it would if drilled in a contracted and narrow line, all other conditions being equal.

Broadcast sowing is objectionable, as irregularity of growth is usually observed, which occasions much difficulty at harvest-time. Planting with the drill ensures a uniform disposition of the seed-corn at regular depth, and consequent regularity of ripening follows.

Early sowing is advocated by many practical farmers. It is doubtless better than very late sowing; but soils and seasons vary so greatly that no rule can be given. Generally a very good time is from the middle of February to the third week in April. February-sown grain gives best quality—April largest quantity. Barley will stand 20° of frost with no injury if the ground be in good condition.

" Barley is now sown considerably earlier than heretofore.
" When the soil is enriched by plentiful manuring, its tempe-
" rature raised by thorough draining, and the climate exposure
" favourable, it should be sown as early in March as possible,
" and will often do remarkably well, though early sowing
" counteracts that tendency to over-luxuriance by which the
" crop is so often ruined in fertile soils. It is chiefly owing to this
" early sowing that the average weight of barley is so much
" greater now than it was thirty years ago. From fifty-four to
" fifty-six pounds per bushel is now about the average weight
" in well-cultivated districts, while fifty-seven to fifty-eight
" pounds is by no means rare. The produce ranges from
" thirty to sixty bushels per acre, thirty-six being about the
" average."[*]

Mr. Mechi, when showing me over his farm many years ago, pointed out the difference between wheat and barley, if planted properly, with very small quantities of seed. In 1861 his crop of barley, sown with six pecks per acre, produced five quarters per acre, was very fine and good, and realised 52s. per quarter. His neighbour, upon similar land, sowed three bushels. This produced the same quantity, but of a quality unfit for malting, and it was sold to a miller for 37s. 6d.[†]

Sir John Anstruther verified this by sowing 3 bush. 5 gal. per acre broadcast, and reaped 36 bush. 5 gal., whilst 1 bush. 3 gal. drilled gave 56 bush. 3 gal. per acre.[‡]

For malting purposes the fine, full, well-developed, bright grain is always considered best, and it stands to reason that with sparse planting the development of each plant can be more perfect, as sufficient space is given it. In wet seasons an additional advantage is derived from this sowing by the greater strength of the straw and the free play of the sun and air between the stems. Laying of the corn, and consequent germination, is also prevented, and mildew is unknown.

By long experiment Mr. Mechi proved that for his land and style of farming six pecks per acre were always sufficient, and generally too much. The usual quantity of seed now used is from three to four bushels per acre broadcast, and two and a-half to three and a-half when drilled. Some farmers say that a larger amount of seed prevents improper tillering and unequal ripening.

It has been often stated as proved that barley repeatedly sown in a light dry soil becomes early ripe, and that sown on heavy moist land late ripe, though originally the same seed.

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[*] Enc. Brit. 1875.

[†] J. J. Mechi, Profitable Farming, p. 180.

[‡] *Papers Bath Soc.* vol. iii. p. 364.

It is not generally suspected by maltsters that the chief harm of irregularly-ripened grain arises from the difficulty of making over-ripe grain grow; yet it is so, for Lauenstein has shown that over-ripe barley lost 53 per cent. of its germinative capacity.

Barley grown upon rich alluvium in river valleys, is well known to be undesirable when malted, in consequence of the excess of gluten, which such corn almost invariably contains.

The plan is very frequently adopted of feeding roots off with sheep, folding them upon the whole field, piece by piece. Although the ground may be ploughed directly each piece is left bare, to "seal in" the droppings, and prevent the escape of their volatile portions, care should be taken that the whole area be planted at one time.

Some recommend that the seed-corn should be steeped for 24 hours prior to drilling, if planted late, but, as barley can safely stand frost, there is little excuse for late sowing. It ought ever to be borne in mind, both by farmers and maltsters, that the value and quantity of the starch of barley is to a large extent ruled by the duration of the growth of the plant.

If barley follow wheat, then three good ploughings at least ought to be given. Freedom from weeds is a very important point throughout all the growth. Barley following wheat favours weeds, and, consequently (coupled with other reasons), many farmers object to the practice.

Barley following beans is still worse for harbouring weeds.

Barley, when standing, is subject to smut, burnt-ear, blight, mildew, and to the ravages of numerous insect pests. All these evils combined in the worst forms do not affect the value of the growth of barley so much as a wet and treacherous harvest.

Too much care cannot be given to the securing and stacking of the crop when fit to cut. It is of course impossible to have each ear of a whole field of the same degree of maturity. This is especially difficult if the fields be small, surrounded with high hedges full of timber. Hence we so frequently find it insisted upon that barley should be grown in wide, open, hedgeless plains.

So soon as the great bulk of the crop upon any given area is ripe it should be cut. Over-ripeness is more to be guarded against by the maltster than premature cutting, for the one is difficult of detection, the other is perceptible at a glance.

The Scotch plan of cutting with the sickle is much to be preferred to mowing with scythes, or the still worse plan of cutting close to the ground with a machine. It is very customary to grow clover or grass with barley. When the barley is ripe this undergrowth is frequently green, and full of sap. The greater the total of moisture present, the longer period has to be allowed for drying, running the chances of rain, and increasing the risk of the stack heating.

Rain spoils the appearance of barley almost at once; two or three consecutive wet days will start germination in the ear.

One of the usual effects of much rain during harvest is heat in stacks. When any heat is generated, it commonly happens that it is sufficiently great to give such indications to a maltster, that he does not attempt to use the barley, and it goes to the miller. To an experienced buyer the characteristics of mow-burnt or rick-burnt* barley are so clear that very rarely is such a buyer deceived. When, however, a stack gets just sufficiently heated to destroy the vitality of the germ, and cools again before any marked discoloration of the ends of the kernels, or taint is communicated, even the most experienced are deceived, if their judgment upon the growing power of barley be formed by the ordinary modes of examination. The heat in stack that cannot be exceeded with safety is, at the utmost, 130°. A small and very narrow stack may get nearly so hot for a short time, but cooling speedily, the barley would be greatly damaged, and yet show no sign, for the scent would be sound, the skin would be fairly bright, and the germ would apparently retain vitality.

It should be made imperative upon farmers to form, in every barley-stack, sufficient vent-holes to give proper ventilation and air. It is a simple and costless thing to do, and in wet seasons would improve the quality of millions of quarters of corn. In no case, also, ought barley-stacks to be made wide.

All barley is improved by heating moderately or "sweating" in stack. Some old maltsters go so far, as positively to refuse samples at any price which have not so sweated, and been stacked at least a clear month. Barley, when purchased by maltsters, has always been threshed from the straw, and separated from the awns. The old plan of hand- or flail-threshing has almost entirely disappeared. The corn is now passed through a threshing machine twice, or if a hummeller be used, then it is threshed and hummelled, or in some cases the grain, after threshing, is spread upon a barn floor, and rolls or some other implement fitted with blunt knives moved about upon it until all awns are broken off, when it is passed through some form of fan, or winnowing machine, and is ready for use. A good crop of barley yields about a ton each of straw, and grain per acre.

The influence of season upon barley is great; were it otherwise, a maltster need not be in possession of much skill. In the absence of scientific attainment, lengthened practical experience confers an amount of skill, that enables a sensible man, with a good memory, to produce fairly satisfactory results year by year. Unfavourable summers and bad harvests often occur, and the experience acquired one season enables an observant man to meet many of the ordinary difficulties with very fair success.

Bad summers affect prices directly. The general average price of barley may not be greatly raised, but good malting sorts may rise 10s., or even 20s., per quarter.

Indirectly, a bad summer, and especially a bad harvest time, will almost invariably cause such defects in barley that the production of really good malt is impossible. The difference in price may not be very great if viewed from the standpoint of first cost, but the deficiency of extract, and the inferior quality of the wort produced, add largely to the actual loss to the brewer.

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* Also termed "goffe-burnt" in parts of East Anglia.

After barley is cut, rain, even in small quantity, is productive of mischief. Old maltsters are of opinion, however,[*] that night-dews are very beneficial in mellowing, and causing the corn to come on for malting much sooner than if it is carried without such damping. Barleys that have not had the advantage of night-dews will not work evenly, or make tender malt, before January.

Dr. W. Schultze[†] states that grain, subject in the field to repeated wetting, suffers from premature germination, the extent of movement of the acrospire depending upon the duration and severity of the wettings and temperatures, &c. In his experience he has found that barley so grown does not invariably malt badly, as in one parcel containing 61 per cent. of germinated corn he found upon malting it that 95·15 per cent. grew satisfactorily, and he arrived at the conclusion that barley having grown corns mixed with it, should not be rejected by maltsters until the number of such corns actually dead be determined.

This gentleman, after exhaustive experiment, has also decided that colour of barley is no certain criterion of its germinating power, as he has found very light coloured barley will not all grow, and that black and red-tipped corns sometimes grow.[‡]

THE INFLUENCE OF MANURES UPON BARLEY.

The wishes of brewers and maltsters have considerable influence upon the proceedings of farmers in cultivating barley. It is, therefore, quite as well for maltsters to recognise the importance of the subject of the direct influence of manures upon barley and malt, which is probably equal to the other two chief factors of success, viz., soil and climate.

Nearly all farmers are agreed that the right rotation of crops is barley after roots. Professor Tanner[§] disputes this, asserting that wheat following roots, succeeded by barley, is best. There is probably much truth in his contention, as nearly all experts are agreed that it is better for barley if manure of a highly nitrogenous nature be avoided.

The reason for this divergence of opinion lies upon the surface. Barley flourishes best in the farmers' interest upon land well tilled and heavily manured, for it grows strongly, and produces heavily. Such barley is not best for the brewer, for it has too high a per centage of non-albuminous nitrogenous matters. If the rank growth of straw has led to considerable laying of the ripening corn, then other grave evils follow, such as staining, imperfect ripening, uneven growth of the grain, deficiency of starch, and other defects enumerated later.

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[*] LEVESQUE. The Art of Brewing and Fermenting and Making Malt. 4th ed. 1847.

[†] *Zeitschr. für das gesammte Brauwesen.*

[‡] See also my experiments, p. 53.

[§] *Rep. Brit. Assoc.* for 1857, p. 206.

Some farmers assert that no manuring is so efficient or economical as July ploughing.

The question has much light thrown upon it by the following extracts :—

Buckman* states that in six plots of Peruvian barley succeeding swede turnips, manured with different manures, he could trace no difference in the barley.

Sir J. B. Lawes writes in his report of the Rothamsted experiments, 1883, as follows :—

"Looking at the character of the seasons, as also at the
" general character of the crops grown, I do not think that we
" shall be very far wrong in placing the unmanured produce,
" when the experiment was commenced in 1852, at from 27 to
" 28 bushels per acre; but when we come to the other end of
" the period it is not so easy to fix upon a precise figure in
" consequence of the seasons having varied very much in their
" character. In 1878 the produce of the unmanured land was
" not quite ten bushels per acre, and in 1879 it was only seven
" bushels per acre; but in 1880 and 1881 it was respectively
" 19½ and 16¾ bushels per acre. I may mention that the
" season of 1880 was one of great abundance, so far as the
" barley crop was concerned; one of our experiments, indeed,
" gave the very large produce of 65 bushels to the acre. It is,
" of course, of great advantage having a large number of
" experiments with various manures which are never changed,
" as it enables us to form a better judgment with regard to the
" general character of each season.

"The mean produce of the last four years of the unmanured
" barley gives 13 bushels to the acre; and I am disposed to
" adopt this amount as the probable yield of the land at the
" present time. This is about the same produce as that grown
" upon the continuously unmanured wheat land; but, at the
" same time, the reduction in the yield has been considerably
" more rapid than in the case of the wheat, as in the course of
" thirty years the decline from the original produce of 1852
" amounts to one-half. That barley grown continuously
" without manure should decline in produce more rapidly than
" wheat, is exactly what we should expect when we consider
" the different character of the two plants. In this country
" wheat is sown in the autumn, and barley in the spring;
" the wheat, therefore, has several more months than the
" barley, during which it can collect its food; and the tendency
" of the wheat plant, moreover, is to send its roots into the
" subsoil, while the barley feeds very close to the surface. The
" best proof we have of the distinction between the two plants

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* *Journ. Bath and West of England Soc.* 1881, pp. 54—63.

" is to be found in the respective action of phosphate upon each " of them. The average increase of barley by the application of " superphosphate has been six bushels per acre over thirty " years; while upon the wheat its action has been very slight— " a fact which proves that the latter plant could find a sufficient " supply in the deeper layers of the soil. A few days ago a " gentleman who had spent a long life in South Australia, while " looking over my experiments, seemed more interested in " these unmanured crops than in any of the others. My visitor " had been dreading the exhaustion of their soils, but, after " what he saw at Rothamsted, said that he should return to " the colony reassured on this point, especially when he found " that, after all our efforts to exhaust the soil, it still retained " the greater bulk of its fertilising ingredients.

" At the present time the produce of our continuous wheat " (which has received no manure for forty years), is from 10 " to 13 bushels per acre; and we have estimated that the " average annual decline has amounted to about one quarter of " a bushel, or about 15 pounds of grain and 25 pounds of straw " to the acre. In the future, however, the decline will not " continue at the same ratio, but, on the contrary, it will be far " less rapid, as the supply of nitrogen in the rainfall and the " very seed which we sow will bear with each decline an " increased proportion to the whole crop grown."

Experiments at Rothamsted have shown that the yield of barley is much more readily influenced by artificial application of manure than wheat. These have been confirmed at an estate of the Duke of Bedford's at Woburn. The experiments lasted seven years, and the following table shows the yields of barley, sown after roots had been consumed on the land by sheep, which gave the following produce in head and tail corn:—

Yield of Barley per Acre, Grown after Roots.

Year.	After roots from cotton-cake dung. The barley not manured.	After roots from maize-meal dung. The barley not manured.	After roots from artificial manure, equivalent to cotton-cake dung. The barley also top-dressed with artificials.	After roots from artificial manure equivalent to maize-meal dung. The barley not manured.
	Bushels.	Bushels.	Bushels.	Bushels.
1878 ..	41·3	38·8	51·4	36·4
1879 ..	38·0	40·6	45·7	32·8
1880 ..	41·3	37·0	41·0	33·4
1881 ..	50·6	47·3	51·0	51·0
1882 ..	51·3	48·1	46·6	46·3
1883 ..	54·4	60·0	60·5	57·8
Average of six years	46·1	45·3	49·3	42·9

Yield of Wheat per Acre, Grown after Seeds.

Year.	After seeds, sheep-grazed with cotton-cake.	After seeds, sheep-grazed with maize-meal.	After seeds, sheep-grazed with no added food. The wheat top-dressed with artificial manure equivalent to cotton-cake.	After seeds, sheep-grazed with no added food. The wheat top-dressed with artificial manure equivalent to maize-meal.
	Bushels.	Bushels.	Bushels.	Bushels.
1878 ..	41·0	43·5	50·6	39·4
1879 ..	39·8	40·0	42·7	41·7
1880 ..	22·0	26·2	21·9	25·1
1881 ..	56·4	57·4	58·9	55·3
1882 ..	42·8	43·3	42·4	46·1
1883 ..	46·1	46·2	44·6	46·4
Average of six years	41·5	42·8	43·5	42·3

Messrs. Wagner and Rohn* published, in 1879, the results of a series of experiments on barley raised from land treated with various manures, as follows (reduced to English weights) :—

I have preferred retaining the ascertained weights of grain to converting them into measures of an assumed gravity.

Manure in lbs. per acre.	Yields of grains in lbs.	Straw in lbs.
None—soil mere sand	3492	3362
17·8 Nitrogen in Chilian nitre	4709	4361
44·6 Soluble phosphoric acid	4076	4005
17·8 Nitrogen as above+44·6 soluble phosphoric acid	4745	4388
44·6 Phosphoric acid in freshly-precipitated calcic phosphate+17·8 nitrogen as above	4995	4558
44·6 Soluble phosphoric acid+38·35 insoluble ditto in phosphorite+17·8 nitrogen as above	5325	4791
31·2 Soluble phosphoric acid+26·75 insoluble ditto in phosphorite+17·8 nitrogen as above	5048	4773
44·6 Soluble phosphoric acid on potassic phosphate +17·8 nitrogen	5503	5797

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* *Centralblatt für Agrikultur-Chemie*, 1879, pp. 515-519.

CHAPTER VIII.

BARLEY (*continued*).

Barley :—
Characteristics, essential, non-essential. Description of Barley. Vitality. Tests for vitality. Skin test. Fire test. Water test. Growing tests. Acid test Age. Condition. Colour of flour. Steeliness. Coldness. Humidity. Age. Mouldiness. Dirtiness. Weevil-bittenness. Brokenness. Awns. Stacking. Maturity; immature, ripe, and over-ripe corn. Odour. Size. Weight. Uniformity. Colour. Appearance of skin.

THE CHARACTERISTICS OF BARLEY.

OWING to the numerous varieties of barley, it is most difficult to convey correct ideas of the characteristics distinguishing it. The fullest and most elaborate compilation of every expressed feature can be at the best but an aid to practice. The positive experience derived from buying, selling, and working barley can in very few individuals cover so wide an area as that which is derived from many minds and authors. Hence the most practical may derive some benefit from the observations of even mere theorists. High theory, combined with exceptional and extensive practice, enables the following results to be arrived at. For malting purposes, I prefer to group the qualities of barley as under—four essentials, and six desirable non-essentials :—

Four essentials of barley needed to make superfine or first-class malt:
1. Vitality;
2. Condition (good);
3. Maturity;
4. Odour (good).

Six desirable non-essentials:
1. Size;
2. Weight;
3. Uniformity;
4. Colour;
5. Appearance of skin;
6. Age.

Malt can stand the most severe test of use which is perfect in the first four essentials, even if it be lacking in one or more of the six non-essentials; but any malt which is perfect in every other particular, but lacks only one of the four essential qualities, cannot be rightly called first-class, nor can reliance be placed upon the beer brewed from it.

In selecting a sample of barley, attention may be given to the percentages present of broken or damaged kernels, seed, other grain, dirt, &c. The presence of these things chiefly affects the cost; and they are all defects easily removed, and appertain to condition. All previous writers have placed the greatest stress upon weight, regarding it as the prime characteristic of good barley; but my own experience has not confirmed this. For the production of superfine malt, vitality, condition, maturity, and odour, all take precedence of weight in any sample. Weight, colour, size, and uniformity are all undoubtedly good points; but they are not essential to the production of really choice malt, when weighed or tested by results three months after use. I cannot but regard vitality as of the first importance. Given two samples, one of which has every kernel capable of growing properly, or the other superior in weight and colour, but with five per cent. of idle corns, and I should unhesitatingly choose that sample upon the growth of which I could depend.

By vitality is meant not only the simple power of growing, but of developing rootlets and plumule strongly and regularly.

The word condition signifies or embraces the following good qualities:—

Softness or mealiness;
Colour of endosperm;

and also the following bad characteristics:—

Steeliness, hardness, vitrifaction, horniness, flintiness, glassiness, coldness, humidity;
Age (positive), reckoned in months or years;
Mouldiness, whether derived in field, stack or granary;
The ravages of insects, or vermin;
Dirtiness, or the presence of other bodies, stones, dirt, &c.;
The damages arising from reaping, threshing, hummelling, and dressing, upon germ or kernel;
The presence or absence of awns: if present, to what extent: if absent, to any detrimental closeness;
The stacking influences, apart from colour, odour, and vitality, and the influences derivable from proper or imperfect sweating.

Maturity is distinct from the age of condition, and refers to greenness, ripeness, or over-ripeness.

Uniformity embraces size (relative not positive), freedom from other grains or seeds, and also uniformity of age (relative), or freedom from mixture of differing growths.

Prior to entering upon a practical consideration of these numerous characteristics, many of which have never before

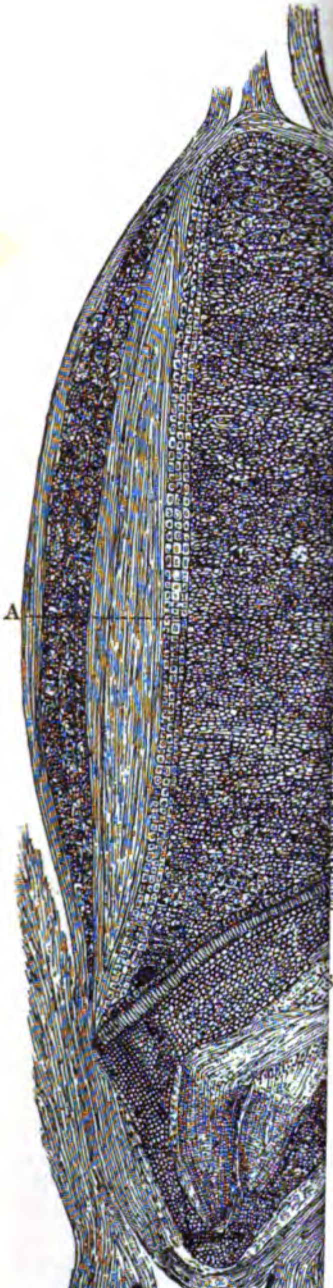

Fig. 3.

Longitudinal Section of B

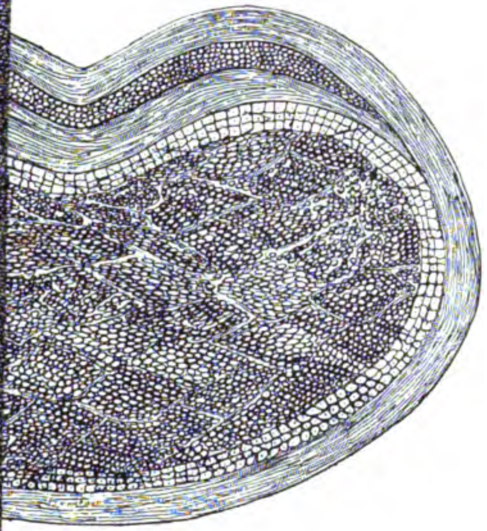

Fig. 3a.

ection of Barleycorn (× 20).

been tabulated, it is necessary to look somewhat closely into the structure of the grain, as revealed by its dissection.

THE STRUCTURE OF BARLEY.

A barley-corn, split longitudinally and magnified, presents the appearance shown by Fig. 3. A cross-section, at the line A B, Fig. 3, gives us the appearance presented by Fig. 3A.

The first glance at these sections irresistibly attracts attention to the relative importance of the germ and skins, and points to the large percentage they represent of the sum total of the grain, which, in common with other grain, is popularly, but incorrectly, regarded as a seed. It is in truth a single-seeded fruit, the external membrane of which is closely adherent to the seed proper, without the intervening pulp of what is commonly termed fruit.

It is slightly attached to the husk (or, in naked varieties, to the spindle of the ear) by the lower end, a longitudinal furrow marking the interior side of the grain, while the exterior side is distinguished by the prolongation of the glume into an awn.

The outer coat of the grain consists of the *paleæ* or valves, separable with ease after steeping. They are found to consist of three layers of cells, each different in form, flat, oval, and elongated. Under the *paleæ* is the testa or shell, consisting of the pericarp and the skin or true coat of the grain.

The endosperm, or starch-body, forms the bulk of the grain, and consists principally of starch cells, but is surrounded by a continuous layer of smaller cells containing gluten, or other nitrogenous compounds.

The germ (presenting, under high microscopic power, the structure of the future plant) is situated at the lower end of the grain on the exterior side.

The lobe (*scutellum*) of the germ forms a broad flat plate on the lower surface of the endosperm; between this and the inner surface of the testa is the plumule (destined to be the future stem, &c.), and the radicle or embryonic root. The plumula shows four leaves enclosing the central stalk ; the radicle has four or five branches, and both plumule and radicle are enclosed in sheaths, which they must rupture in course of development, in addition to the exterior coats of the grain.

The most important factor in the consideration of the value of barley is its composition, which is only approximately ascertained by even the most elaborate analysis, but the results of any analysis are of considerably more value than the shrewdest guessings prompted by practical experience alone.

PRACTICAL CONSIDERATION OF BARLEY, WITH TESTS FOR DEFECTS.

The order in merit of the qualities of barley for malting has been already given (see page 79). Adhering to that order, we have first to consider vitality.

I.—Vitality.

To the very experienced and skilful eye, vitality, in common with many other of the characteristic qualities of barley, is capable of being more or less promptly determined; and also the commercial value of the particular sample under inspection. On few other points than vitality, however, can the experienced judge be so readily led astray. This arises, doubtless, from the indifference usually felt by maltsters as to the perfect germination of the malt made. More attention is usually given to weight, colour, and condition, though it is obvious that these qualities are of less moment. Until very recently brewers have been content with malt containing considerable percentages of unmalted grain, but such contentment is destined to pass rapidly away.

Upon the vitality of barley depends the growth; consequently differences of vital force of germ extend throughout the whole period of germination, unless means be taken to foster, or retard growth, according to circumstances.

The vitality of barley prior to steeping is influenced in the following manners:—

Imperfection of growth arising from varied causes prior to ripening;

Incipient germination in ear, shock, or ground, occasioned by wet in harvest (corn which has once started rarely grows again);

Death of germ, caused by over-heating in stack, stagnation, or improper storage in granary, and too high heat in kiln when sweating; destruction by weevil, corn-worm, or grain-moth, partial or total destruction by threshing machine, hummeller, spades, boots of workmen, or other agency;

Loss of vitality through age, drowning in cistern, or excessive cold.

Barley does not readily grow after the second year, no matter how much care may have been given to its storage. Too lengthened steep practically drowns weak kernels.

Frequently barley is found to grow badly immediately after harvest, and to improve as spring approaches. Samples which have never been properly stacked suffer in this respect very considerably. By actual test it has been proved that corn of which only 30 per cent. grew in autumn, so many as 98 per cent. grew in the following spring.

M. de Saussure,* in 1826, instituted an elaborate series of experiments on the degree of drought, which germinated grain could endure, without final loss of vitality. Barley, of which the radicles were as long as the grain, and the plumule nearly free of the husk, was kept for some days at 95°, and then for two months at 60°, but revived on being placed between damp sponges for eight days. At an earlier stage, when the radicles were but half as long as the grain, it survived an additional month in vacuum over sulphuric acid. Whilst germinated barley, even after two months' slow drying, was killed by two hours at 150° Fahr.; ungerminated barley bore 207° Fahr. without injury, but required longer damping. Wheat and rye in the earliest stage of growth survived 150° Fahr. The test of vitality is the relative loss of entire grain and of crushed grain in vacuum; grains that show a wide difference being able to withstand drought better than those that lose moisture from the whole grain as quickly as from the crushed. A month in vacuum gave the following results with barley:—

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* *Mém. Soc. Phys. Hist. Nat. Genève*, t. iii. pt. 2, pp. 1—28 [1826].

Meal lost 11·94 per cent.; whole grain 6·8 per cent.; chitted ditto 6·8 per cent. The more advanced grains require longer damp to revive them: the rootlets always perish.

Krasan[*] states that wheat thoroughly dried, by very gradual heating with help of calcic chloride, will bear 212° Fahr. for several hours without dying.

Signor Missaghi[†] has published experiments proving that grain which has been sufficiently moistened to swell, has its vitality imperilled if not destroyed.

Two quantities of wheat, alike in all respects, were taken, one saturated till the grain swelled, the other merely wetted. Both were kept for six months in pure carbonic acid gas, and then sown; the swelled grain turned brown and died, the others grew.

Eberhardt[‡] finds that germinated rye, allowed to grow varying periods and then dried, could revive, thus:—

Grew 18 hours ... ... 96 per cent. revived
,, 103 ,, ... 54 ,, ,,
190 hours seems to be the limit.

Tests.

The majority of the evils that produce want of vitality are capable of instant detection. The remainder can only be determined by the exercise of considerable skill, care, and some simple test, or by the actual test of enforced germination.

Incipient or partial germination, in field or elsewhere, may be recognised by the slight development of the cotyledon, and the softness or friability of the end corresponding with such development.

If the growth has been sufficient to develop rootlets, these will be readily detected.

The death of germ may be usually determined by carefully removing, with the thumb-nail or a knife, the skin of the end of the corn over the germ, and with a weak lens examining it carefully. If alive, the germ has a juicy, fairly firm, yellow appearance, very closely resembling, in consistency and colour, good firm freshly-churned grass butter, or of a greenish-yellow colour, very like wax. Any other appearance is evidence of some defect. Should it be reddish brown, dark, or black, or dried and shrivelled, it is dead, and nothing short of gelatinisation can make malt of it. If grey, then the vitality is low.

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[*] *Chem. Centralblatt*, 1873, p. 755.
[†] *Gazz. Chim. Ital.* vol. v. pp. 418, 419 [1876].
[‡] *Chem. Centr.* 1882, pp. 320—322.

Fire Test.—Take from a clear fire a large good red cinder, which should be kept by artificial blast at an uniform heat, place carefully upon it, one or two at the time, kernels of the sample being tested. If the corns dance about, it is reasonable to conclude they are alive, and the bulk will grow. Those that simply cremate in a passive manner are dead, and the proportion of such corns rules the value of the sample.

Water Test.—Drop corns individually and slowly into an open dish or tumbler of water. Notice carefully the mode of subsidence of each one. Those corns which wriggle in descending, and exhibit a tendency to stand up in any way, have some defect. Good healthful corns fall to the bottom quickly and steadily, and lie evenly and horizontally. This test is considerably used in several countries of Europe, but it is too unreliable to be worth the trouble, especially as it is at times entirely wrong, for a disturbance of the disposition or arrangement of the starch cells will affect the action of the corn in water to a greater degree than the vitality of the germ.

Growing Test.—The most decided and reliable test is that of enforced growth. This is effected in several ways. Some maltsters take a sample of the barley under test, about half a pint, and tie it up loosely in a small bag. This is then placed in the cistern with a full steeping, and steeped in the ordinary way. When it commences to chit, 100 corns are counted, and the number of dormant kernels is reckoned the percentage of dead corns.

This method is slow, tedious, and unreliable, for many corns that eventually grow strongly and well, appear dead for a week or longer if steeped in this way.

Another method is to count 100 or 200 corns, and place them in flannel on a plate or other flat dish, and put them in soak for 24 hours; then, drawing off the water, the corn still has power to absorb the moisture retained by the flannel, and gets free access of air. If the sample is kept at a temperature exceeding 56° it will chit in 36-50 hours. It is important to bear in mind that any temperature exceeding 50° affects the germinative capacity of barley, consequently, if the test-sample is allowed to stand in a warm place in order to save time, the number growing may be considerably less than the number that could grow at lower temperatures.

Another and better plan is to place the corn in a layer of moist sand, covered with wet cloth or blotting paper.

Nobbe's apparatus is better still. It consists of a tray or plate of lightly-baked, very porous, clay, studded with any definite number of small indentations or holes. The corn placed in these readily absorbs moisture, and, being fully exposed to the air, grows freely and quickly.

The Coldewe and Schœnjahn apparatus is apparently the most effective and reliable for the purpose of testing vitality, for it gives certain indications of the relative vigour of corns, as well as merely deciding the question of the power to grow at all.

This patented arrangement consists of a small glass vessel, with a neck, contracted about one and a-half inches from the top, which receives a tray of porous or enamelled porcelain. This tray has 100 indentations, capable of retaining as many kernels of barley. This is surmounted by a pad of felt fitting the glass, and attached to a cross wooden frame, to which is also affixed a small thermometer. The use is very simple. Any sample of barley requiring to be tested is placed on the tray; one kernel, with the germ downwards, in each hole. The glass is nearly filled with water, and the tray is then placed on the ledge, or indentation. A small quantity of sand is placed round the barley, and is wetted with water. The felt is placed over all to prevent undue evaporation, and it is left in any moderately warm place for the corn to germinate. The temperature is easily ascertained by the thermometer. As soon as the barley begins to sprout it can be examined. The sluggish corns, and, indeed, every different quality of grain, is determined at a glance. If retained for a few days, the different degrees of vitality become more clearly marked. Many similar plans and contrivances are in use in Germany and elsewhere.

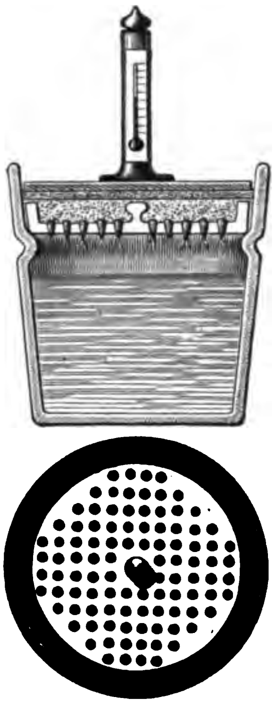

FIG. 4.—GERMINATOR. Coldewe's Patent.

Acid Test.—All the preceding tests require at least 24 hours for practice, and most of them considerably longer time. It follows that they are useless to a buyer in ordinary corn markets, and practically of little use to maltsters who have samples submitted at their own offices, excepting in the case of foreign cargoes, or very large bulks, when time is granted for the express purpose of testing. Haberlandt discovered a process of germ-investigation of great utility and very considerable accuracy. Carefully divide a corn longitudinally into two even halves with a *sharp* knife. This division splits through the germ, which can then be examined, and should present the appearances already indicated. Should there be the least suspicion that it is not perfectly vigorous, apply one drop of concentrated pure sulphuric acid.[*] In a very few minutes a dead germ turns nearly black, a weakly or feeble germ becomes brown, the precise tint furnishing roughly an indication of its strength, but a healthy, vigorous embryo assumes a fair rosy tint. Rapid as is this mode of investigation, it nevertheless is tedious and almost impossible to practice commonly in corn markets, where sales are effected by the plans common at this time.

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[*] The stoppered-jet bottle used by mineralogists would be of use for this purpose.

The greatest age at which barley vegetates is stated to be three* years. Of 300 kernels that had been kept for three years in a jar, 167 vegetated. Of 300 preserved in wax cloth, 236 grew.

The following table only faintly indicates the indefatigable labour bestowed upon the investigation of this subject by Professors Daubeny, Henslow, and Lindley.

Result of experiments conducted in 1841–1857 *by the British Association Committee on the growth and vitality of seeds.*

Grain	Age in Years.	Number sown.	Number vegetated.	Range of per centages.
Barley	1	300	255	71-94
,, ...	3	300	167	15-86
,, ...	3*	300	236	63-90
,, ...	8	300	—	—
,, ...	13	300	—	—
,, ...	16	300	—	—
,, ...	50	200	—	—
Mummy	?4000	100	—	—
Oats	1	200	180	90
,, ...	3	300	237	57-91
,, ...	3*	300	210	41-95
,, ...	8	200	37	13-24
,, ...	13	300	—	—
,, ...	16	300	—	—
Rye	1	600	456	—
,, ...	3	600	4	2
,, ...	8	600	—	—
Wheat	1	200	180	82-98
,, ...	3	300	163	33-86
,, ...	3	150	115	80
,, ...	3	300	139	26-65
,, ...	3	300	140	40-58
,, ...	8	300	—	—
,, ...	9	100	—	—
,, ...	16	150	—	—
Mummy	?4000	100	—	—
Maize..	1	300	198	9-98
,, ...	3	300	127	24-69
,, ...	8	300	—	—
,, ...	13	100	—	—
,, ...	15	100	—	—
Peruvian Tombs ..	?2000	12	—	—

If sound barley is carefully dried at a temperature of from 120° Fahr. to 140° Fahr., and then stored in a dry place, entirely excluded from contact with the air, it retains the power to germinate for 12 years or even longer. Egyptian barley, taken from the ancient tombs, is *reported* to have grown after a burial of 2,000 years or upwards. This statement still requires proof.

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* Preserved in waxed cloth.

It is usually desirable to carry over, each spring, sufficient kiln-dried barley to last for October and November, so that the new corn may have time to mature properly.

II.—CONDITION.

The extended definition of condition embraces so much that, if my rendering of its meaning be accepted, it ranks next to vitality. To my mind, the one word "condition" covers the whole sphere of the following characters of barley:—

Mealiness, softness of starchy portion of grain (endosperm).
Colour of endosperm, as distinguished from colour of skin, the so-called "colour" of barley.
Steeliness, hardness, vitrifaction, horniness, flintiness, and glassiness. Chiefly synonymous terms, but all distinguishable from colour of flour.
Coldness.
Humidity.
Age (positive), as reckoned in months or years.
Mouldiness, whether derived from field, stack, or granary.
Dirtiness, occasioned by the presence of dust, dirt, stones, strings, metal, or other rubbish.
Weevil-bittenness. The ravages of insects or vermin.
Brokenness. The damages arising from reaping, threshing, hummelling, or dressing upon germ or kernel. Probably barley is more broken this year than at any former time (1884).
The presence or absence of awns; if present, to what extent; if absent, to any detrimental closeness.
The stacking influences, apart from colour, odour, and vitality. The influences derivable from imperfect sweating, either in stack, or upon kiln.

Softness, Colour, and Steeliness.

A corn of barley, when bitten or cut crosswise in the centre, furnishes a fair index of some of the phases of its general condition. If the endosperm is white, friable, or mealy, its composition is favourable to making good malt; should the colour be other than white, it furnishes a fairly accurate indication of some defect, and its cause. If when bitten it has a bluish cast, similar in tint to skimmed milk; or, if dirty, inclining to brown or yellow, or any variation of red, yellow, and brown, it is unkindly, and requires special care and skill in making up. A harsh, hard, brittle kernel, which shows a conchoidal fracture, indicates an excess of gluten or protein-substances. Haberlandt, Leuthold, and Holzner regard these indications as the result of the manner of growth, and arise from the starch-cells being too closely packed. They undoubtedly prove that the starch-cells consist of imperfectly developed and small granules of a close, dense, stubborn kind, and all such corn is best left unsteeped, if better can be obtained.

Some people assign, as one reason for this, the growth for many consecutive years upon the same soils of a particular stock without change of seed corn. The edges of the grains of barley nearest the top of the ear, which are last formed, are often the most vitreous. Corn which during its growth has not had enough moisture, or favourable weather, becomes grey and vitreous. The teeth and eyes are generally sufficient to determine these characteristics, but it is well occasionally to confirm the judgment by close careful inspection of such corn by the aid of a good microscope.

Coldness and Humidity.

Some samples of barley feel cold and dead to the hand. This may arise from three causes.

1. Imperfect ripening or immaturity.
2. Imperfect or insufficient sweating in stack.
3. Retention of a considerable quantity of moisture.

If coldness arises from immaturity, corn when bitten will have a dull greenish tint. The defect arising from inadequate sweating in rick is comparatively rare, and occasions coldness in most cases, when it is found that it is not caused by immaturity or damp. That which is caused by damp is made apparent to the touch, or the manner in which a corn yields to the teeth when bitten. The most certain method of ascertaining this last is, however, by exact determination of the percentage of moisture present. This is readily done by finely grinding, and accurately weighing, any given bulk, placing it in an air bath until perfectly dry, and again weighing the dry corn. The loss gives with sufficient exactitude the amount of water present in the grain.

The humidity of grain is an important factor in prime cost, especially in all cases where the barley is bought by actual weight. It necessarily follows, if 15 or 20 per cent. of water is present, that, as it nearly all disappears in malt, it represents an actual loss. This subject will be taken up more fully when considering growth. The harm to condition produced by moisture is considerable, as all damp barleys are more difficult to work. They should, however, never be steeped unless they have been properly sweated upon the kiln.

If for any reason damp barleys are stored or kept, great care should be taken properly to dry them prior to putting them in store. After proper kiln-drying they can be kept, even in large bulk, with perfect safety for many months. If, however, they are stored damp as received, they should never be placed at a greater depth than four feet, and be turned over never less than twice a week. The plan of keeping such barleys, or indeed, any barleys undried, cannot be too strongly deprecated.

The embryo of all barley is very delicate. If any dampness exists in the corn, it naturally affects the germ first, and, apart from its power to encourage mould and occasion bad taint, it seriously imperils the vitality of the grain.

Age.

It has been already shown that age of barley very seriously affects its vitality generally. The age (positive) also very greatly influences condition. Barleys of different seasons should under no circumstances be mixed, for it is simply impossible to make them vegetate uniformly.

No truly reliable test of old barley has yet been invented. The indications by which an experienced buyer can detect it are too subtle to be conveyed by words. Darker yellowness of germ is the most easily-expressed sign. Like many other points in malting, it can be acquired with certainty by long experience only. It very rarely happens in practice that the attempt is made to sell old barley as new, although it is occasionally done.

Some maltsters assert that new barley gives twice the increase of old corn.

Mouldiness.

It is no exaggeration to say that probably no barley is entirely free from mould. For all practical purposes, good, clean, bright, untainted corn may, however, be regarded as being free from mould when steeped. Some corn is known by the farmer to be affected by mould prior to its sale. This mould may arise from blight, mildew, or the attachment to the straw, or ears, of the spores of mould in the field. These spores are placed occasionally in favourable condition for reproduction and development in the rick, stack, or barn. Should they not develop in those places, then it sometimes occurs that improper storage of grain in bulk causes their development, and the barley gets "granary taint" in consequence, which is simply evidence of the spread of mould.

As mould spoils both colour and smell, unscrupulous dealers carefully redry it, putting brimstone or sulphur upon the fires, so that the sulphurous fumes may not only eradicate the smell, but also improve the colour.

This fraud is readily detected by placing the sample in a tightly-stoppered bottle, slightly damping it, and placing it in a fairly warm place (60° to 90° Fahr.). In one or two hours the original mouldy taint can be distinctly detected, if the suspected sample has been doctored. If after two hours no taint be present, the corn is sound and in fair condition, so far as mouldiness affects condition.* By grinding the barley to powder, and mixing it with hot water, keeping it constantly stirred, the scent of sulphur is clearly distinguished. (For a further test for sulphuring see "Colour.")

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* This practice is rapidly increasing in America, Bohemia, and many other places, and is strongly condemned by Professors Lintner, A. Belohoubec, Thausing, &c.

When barley is badly tainted by combined mould and protracted exposure to wet or damp, in addition to sulphur, very finely powdered chalk is used. Close inspection in a clear light with good eyes, or with a weak lens, will readily detect this, and, if detected, the sample should be rejected at any price, for this artifice is rarely, if ever, resorted to except in bad cases. If the spores of blight, mould, or, indeed, any low organism, happen to adhere to the grain, the process of examination under the microscope will reveal them, but for practical purposes it is too tedious a process.

In every case in large maltings employing power, it is advisable thoroughly to wash and clean the barley immediately prior to steeping.

Not only does mouldy barley contain elements of grave danger to the success of the maltsters' and brewers' operations, but the fact that it has been under such conditions as are favourable to mould, is a sure criterion that it has been running grave risk of danger to its vitality.

Dirtiness.

Farmers rarely clean corn perfectly, consequently all samples contain some undesirable foreign matters, and, in the aggregate, the immense diversity and amount of dirt and refuse are appalling. Dust, dirt, stones, sticks, string, metal, and odds and ends of every sort and degree are to be found. Experience has taught that no heap of 1,000 quarters of grain ever contains less than many hundreds of metallic fragments alone. Stones abound in even greater number. Buyers customarily throw a handful of the corn several times into the air in such a manner that a slight twist is given to it. This speedily brings to the surface, or at one edge, all the extraneous matters contained, and reveals the proportion of the whole bulk they occupy.

The total amount of refuse present in any sample naturally regulates the value and condition of such sample. With the exception of stones, or other substances of the same size and form as barleycorns, they are all capable of easy removal, and their presence is naturally very easily detected.

Weevil-Bittenness.

The ravages of weevils or other insects, and of mice, rats, or other vermin, are occasionally serious. Out in the fields, in stack, or in granary, corns are nibbled or bitten by rats and mice. Bitten kernels are easily detected, and, if present in any quantity in a sample, it should be rejected. Not only do they not grow, but they become the centres of putrefactive activity.

Of the insects, the most destructive is the common weevil (*Sitophylus granarius*), with which all maltsters are familiar. Weevils are also called variously bood, whool, and pope. Should barley be stored for early autumn use, and remain in store for six or eight months, the ravages committed by weevil can be immense. They scoop out the whole of a corn, leaving the husk apparently intact but perfectly empty, and if the weevils are numerous the quantity of grain so destroyed is large.

When these insects once make a firm footing in a malting or barn it is most difficult to eradicate them. Almost every conceivable method has been tried. Short of demolition of the building, few are really successful. This trait, coupled with their rapidity of propagation, makes the purchase of corn attacked by them of grave importance, for it may readily prove a means of introducing them into a new building. The white corn worm (*Tinea granella*) and the larvæ of the grain moth (*Gelechia cerealella*) are more rare, and their ravages are seldom met with.

No tests other than sight are needed to detect any of these defects in corn.

Brokenness, or the Damages arising from Reaping, Threshing, Hummelling, and Dressing of Corn.

Formerly barley that was flail-threshed and trodden was deemed superior to machine-threshed, in consequence of the comparatively small number of corns injured by the hand processes compared to the machines. If an ordinary threshing machine is out of order, or improperly fed, the number of broken and damaged kernels is very large, in some cases amounting to three per cent. of the whole sample. Not only is the three per cent. of corn lost, but, as each broken and bruised corn becomes a centre of contagion, communicating mould and putrefaction freely to otherwise clean and healthy corn, the mischief done is very great.

All men engaged in shifting or working corn in any way, almost invariably crush some or many corns with the heavy hob-nailed boots commonly worn. It is very general to find sharp steel or iron shovels employed in shifting or moving grain.

These and other practices of a like nature ought to be discontinued. All such practices, combined with the exceptional character of the summer this year (1884), have resulted in making almost every parcel of barley extremely full of half-corns. As they can all be removed at a total cost of less than 6d. per quarter, it requires no lengthened demonstration to prove the desirability of eliminating them from all barley prior to steeping.

A further indication of condition is furnished by the absence or presence of awns. Unduly long awns are objectionable in all cases where corn is bought by measure. Awns broken off too closely to the kernel are bad, as all abrasions of the skin are harmful to the extent in which they admit the direct contact of the steep liquor with the endosperm, and favour the production of mould. In some districts the objectionable plan exists of allowing an extra price of 1s. and upwards per quarter on barley weighing over 56 lbs. per bushel. This induces farmers to dress very closely, and the great harm results already described.

The condition of the awn is of course easy of determination by sight.

The stacking influences, apart from colour, odour, and vitality, and the influences derivable from imperfect sweating, either in stack or upon kiln, are of considerable importance. If a stack heats only very slightly, or if barley is threshed within three or four weeks after cutting, it is obvious that no sweating can have occurred.

All maltsters assert that this sweating is beneficial throughout all stages of steeping, growth, and to the malt when finished. What precise modification of the constituents of the grain occurs by this heating is not yet clearly determined, but that it does aid materially the healthful development of the germinating grain cannot be doubted. Nor has any well-defined test yet been devised to enable a buyer promptly to determine if any sample has so sweated. As a consequence, it is safest to assume in all cases that it has not taken place, and to make the necessary arrangements to sweat all corn upon the kiln prior to storage or use. A kiln built upon my principle enables sweating to be accomplished at no cost for fuel, hence the sole expense is the labour needed. Corn is rarely sold after being kiln-dried. If, during the process, the heat has been sufficiently great to imperil the vitality of the germ, it is easily detected by examinations indicated under the heading of "Vitality" (pp. 85-89). No test for inadequate sweating has yet been published. If any doubt upon the subject exists, it can be remedied by placing the corn a second time upon the kiln. The best course is to determine the percentage of moisture present.

III.—MATURITY.

Barley may be immature, ripe, or over-ripe. It is of great importance, therefore, to a maltster to secure such corn as contains the largest percentage of properly mature, fitly ripe kernels. The reasons why it is difficult and rare to find any sample consisting of corns all duly mature have been already explained.

Immature or unripe corn is particularly objectionable, for it has its constituents in a crude, or stubborn condition, and it cannot be induced to grow. Such corn is always in very poor condition—cold, of a sickly greenish, or greyish-yellow colour, and, if dry, of a starved, crinkled look. The germ is also usually in a very shrivelled or dry state.

Over-ripe corn is more difficult to determine at sight, but as it grows very badly, it can be easily detected by any of the germinating tests. It generally contains a greater percentage of protein-substances. It has frequently a deader white appearance of skin, but the condition of the endosperm is rarely altered to any visible extent.

An experienced buyer, when examining a sample, closes his hand over a quantity of kernels to feel the effect of slight pressure upon them. He then allows a fair number of corns to slide down his palm several times. By the ease with which they do this, and by noting the relative degree of smoothness with which they slide, a fair criterion of the maturity of the grain is afforded, for only plump, properly filled, and therefore smooth kernels will glide off the hand freely and smoothly.

Corn is not necessarily immature or over-ripe which is not plump or well-filled, for much fully-developed good English and very much foreign barley is decidedly thin.

As the gravest defect of immaturity is irregularity of growth, the tests for vitality are sufficient to answer all practical purposes in testing maturity in doubtful cases.

IV.—ODOUR.

The last of the indispensable characteristics of barleys that are qualified to produce first-class malt is a good and proper odour.

Barley that at any time contracts any taint, or smell, can never make absolutely good malt, however skilfully it may be worked, or cunningly doctored, to deceive those brewers whose judgment of malt is formed from mere hand-tests, and based upon lengthened experience.

Sound, pure, untainted corn has a peculiar, clean, slight odour, almost imperceptible, and difficult to describe in words. Once learned it is ever afterwards readily recognised.

Any other scent, however faint, is sure indication of evil of some form. Odours more or less bad are communicated by the following causes:—

Improper exposure or neglect in swathe upon the ground, or in the field; frequent damping from rain or heavy dews; contact with other plants or noxious weeds (garlic, &c.); and storage in ship with or after guano, petroleum, &c.

Stacking before being properly dry, or with too great a quantity of other plants, and consequent heating, mustiness, or mould in stack.

Improper storage of grain in a damp, or mildewed condition, &c.; keeping at too great a depth, and infrequency of turning in store.

All or any of these are undesirable, and some are positively harmful; the worst are occasioned by mould in varied forms. Samples are sometimes drawn from bulk, and exposed to the air and sunlight, or, if very bad, are kiln-dried and sulphured. The best mode of detecting the practice has already been given (p. 91).

The sense of smell needs no guiding by tests to determine any other of the numerous forms of mal-odour occasionally encountered.

I.—SIZE.

The size and shape of individual kernels are points of some importance. Short, smooth, plump, comparatively round kernels are usually considered the best. Not only does the size and shape affect the disposition and value of the kernel from the nature of its constituents, but it very materially affects the relative percentages of all the constituents.

The proportion of husk and germ, or of cellulose, gluten, ash, oil, &c., in small corn is very much greater than in large big grains, which naturally have a higher percentage of starch, &c.

The following analyses by Woolny show this more clearly :—

	Water.	Starch.	Albuminoids.	Cellulose.	Ash.
Small thin corn	9·70	68·86	12·57	6·29	2·58
Large plump corn	10·93	70·35	11·51	4·79	2·42

Barleys all of the same shape or size naturally work much better together in steep or on floors. It almost invariably occurs that thin corn grows more quickly, and starts earlier, than larger grain.

The importance of wetting only big corn, in consequence of the difference to cost made by the levying of the Malt-tax, no longer exists, consequently if all other characters of a sample are favourable, size should be no impediment to making malt of thin, even very thin, foreign grain.

The length of a barleycorn is probably little altered now from those early periods when a barleycorn was taken as a standard of length, three barleycorns making one inch ; but in circumference the corn has increased considerably in consequence of improved cultivation.

Thirty years ago Dr. Thomson[*] made an elaborate series of experiments, and determined the size, weight, &c., of barley, but the maximum sizes are now very commonly exceeded. The difficulties attending the effort to take a true average are such that we may fairly assume any attempt to establish a standard of size more or less futile.

Size is commonly judged by the eye only, with no actual assistance of any test, but the real sizes of a particular sample are capable of easy determination by sifting in a series of small sieves, having the meshes of each arranged slightly larger than the other, so that the quantity of corn retained upon each sieve gives at once a clear indication of the sizes of all the kernels.

II.—WEIGHT.

Nearly all previous writers have stated that weight of barley is of the greatest importance. Although profoundly respecting the opinion and admiring the knowledge of many eminent writers, I do not feel disposed to assign to weight, priority over any of the properties of corn already tabulated. Although I am quite aware that for extra quality malt for delicate pale and stock ales it is desirable to select heavy corn, still it is not so important as vitality, condition, maturity, odour, or size, and I much question if it really more than equals uniformity of colour.

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[*] Dr. T. THOMSON, Brewing and Distillation, 1849, p. 14. See also Enc. Brit. ed. 8.

For common or running beers, moderately heavy corn is sufficiently good, and a thin light French or Mediterranean barley will make much sounder, more useful, and cheaper extract than a heavy, rough, Scotch barley. Nevertheless, the prices of corn are ruled in nearly all markets by weight, and it is therefore one of the gravest characteristics.

Any barley which weighs 56 lbs. per imperial bushel, or upwards, may be called a heavy barley. All under 50 lbs. per bushel may be deemed light, excepting bigg and barleys of its class (*H. hexastichon*). Weight is ruled or influenced by other factors than size, such as the degree of maturity, the structure and arrangement of the constituents of the grain, or the humidity.

Over-ripe or fully-matured barley is heavier by two or more pounds per bushel than unripe barley, otherwise alike in all respects of size, species, &c.

Vitreous barley always weighs more than similar corn which is friable.

Dry corn is usually lighter than wet.

When weight is calculated from small samples, due care must be taken to allow sufficiently for the difference in weight of a small loose sample, and a larger bulk. For this reason the use of the small spring-balance chondrometer, fitted with a filling cone, is the best method of testing the weight of barley from a small sample, but much care and practice are required to ensure reliable results.

III.—UNIFORMITY.

The great bulk of barley when brought to market consists of a diversity of corns, differing very materially in size, colour, and maturity. These differences affect the value of the malt made, as it is of importance to have samples regular or uniform.

Barley which is grown in small irregular fields, in the shadow of woods, or heavy hedgerow timber, upon variable or springy soil, cannot possibly be uniform. The influence of these differences is, however, greater upon the character of the corn when working, than commonly, upon the price of the malt, for barleys differing in size rarely if ever grow in precisely the same manner, and consequently malt resulting from such working is necessarily imperfect.

The difficulty of attending to such details renders it the more imperative to sift, sort, or screen barley, so that uniformity of size and shape is secured, for without it uniformity of growth, and even (regular) malt is rarely or never attained.

Among the many altered conditions of the trade at the present time, a number must not be overlooked, that are ruled by natural laws, or only very indirectly by statute.

Increased facilities for transporting grain and beer have enabled enormous breweries to be developed. To supply them with malt, very large maltings have been erected, and in such great establishments it is impossible for each individual growth of barley to be kept separate when working.

In the smaller maltings that were formerly so abundant, it was not unusual for the whole of the barley wanted to be grown within sight of the malting. The maltster knew exactly the nature of the soil upon which the great bulk of his barleys grew. In many cases he actually knew how the corn had been harvested, and many other details, which enabled him to turn out malt of an excellent quality. It often occurs that a comparatively small field will yield a variety of qualities of barley. Variations of soil and differing degrees of humidity from the position of springs, and the "lay of the ground," will cause differences in size, and the degree of maturity of the corn that cannot be avoided. When, therefore, a malting draws its supplies from widely extending points, attention to such minor details as mixing growths cannot be given. When foreign corn is used, this point has to be utterly ignored.

Malting in Ireland is found to be unsatisfactory, in some senses, from this very cause, for the patches grown are usually small, and it is rarely that a good quantity can be secured at once. As it is the custom in Ireland for maltsters to buy very largely in autumn, and so accumulate large stocks of corn, which are further mixed in sweating and storage, the uniformity secured by separation of particular growths is rarely possible. The evenness of size attainable by proper screening and grading can, however, take the place of purely local knowledge, and it is desirable in every case that at least the uniformity of size so readily attainable should be secured. Corn which is all of one size naturally steeps and grows better than similar corn greatly differing in size. Maltsters formerly gained considerably by closely screening out all thin corn to avoid payment of duty. It still pays to remove thin corn for the sake of the uniformity of growth it favours. Its necessity is still further pointed out later on.

IV.—COLOUR.

Colour furnishes a very fair general indication of the quality of barley, for the simple reason that those conditions of climate, soil, &c., that favour colour are best for the production of corn that possesses nearly all the other essential or desirable qualities already enumerated. In Great Britain it is rare to secure barley which has not become more or less discoloured from rain or damp. Some foreign corn is gathered upon which no rain has ever fallen. The difference in colour is naturally considerable.

The whitest barley is not invariably the best, but still it is a fairly safe rule,—"The lighter the colour of the barley (if natural) the better the malt." Light, straw-yellow is usually good, and strong, bright yellow is better than a washed, or sulphured, lighter-coloured corn.

The practice of kiln-drying and sulphuring corn to improve its colour and smell is not yet common, but it requires to be guarded against. If a sample is suspected at all, let it be soaked for a few minutes, and well washed in pure distilled water. Then add to the water, after draining it from the barley, four or five drops of chloride of barium. If a thick white precipitate occurs it is proof of sulphuring upon kiln.

The colour of the tips of the kernel should be of the same tint as the rest of the skin. Dark tipped or black ended corn has usually been subject to such conditions of heat, wet, or age as are fatal to uniformity of growth, and usually destructive of vitality.

Corn usually assumes a darker tint by long storage, and loses to a great extent the power to germinate regularly.

Thausing* approves most of barley which is harvested when yellow ripe, preferring that which in colour is of a light straw yellow. If the corn has a greenish colour, it is an indication that the barley could not have been ripe when cut.

V.—APPEARANCE OF SKIN.

By the appearance of the skin of barley, direct evidence is furnished of material use in determining the value of the corn.

Thin wrinkled skins denote kindly, properly matured, useful barley. They should not be too thin to retain the acrospire properly.

Thick, harsh, rough, crinkled skins are caused by bad or unfavourable growth on harsh, cold, stiff soils, and they denote barleys more or less difficult to work, which are generally stubborn and sluggish. The malt made from them never looks well, and the percentage of husk is much higher than in thin-skinned barley, which may seem similar in all other respects.

Thick, rough skins denote the possession of an excess of extractive matter in barley, which has to be removed by frequent change of steep-liquor.

Some writers consider the appearance of skin the most important indication of the quality and value of barley. I fail to see how I can give it any other position than the end of this chapter.

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* Preparation of Malt and Fabrication of Beer (American Ed.), p. 192.

CHAPTER IX.

BARLEY (*continued*).

Barley :—
Chemical composition of Barley. Empirical Analysis. Starch. Size and Character of Cells. Conversion. Cellulose. Dextrine. Sugars. Fats. Cholesterin. Resins. Ash. Analyses of Ash. Nitrogenous Substances. Glutens. Analyses of Glutens. Albumen. Caseine. Fibrine. Gelatine. Mucedine. Amides. Peptones.

CHEMICAL COMPOSITION OF BARLEY.

The empirical composition of barley is given by Drs. T. and R. D. Thomson, as follows[*] :—

Carbon	46·64
Hydrogen	6·02
Nitrogen	1·81
Oxygen	37·66
Ash	3·41
Water	9·46

It is essential to know also the molecular composition of barley. External appearances sufficed for the practical maltsters of the past, but no true reliance can be placed upon these, and the determination of the real character of the grain is greatly aided by the researches of chemists.

The divisions of the subject that follow naturally the usual composition of the grain are :—

I. Non-nitrogenous bodies.
    Starch.
    Cellulose.
    Dextrines.
    Sugars.
    Fats.
    Resins.
    Ash.

II. Nitrogenous bodies (proteins or albuminoids).
    Glutens.
    Peptones.

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[*] **Report on the Effect of Barley and Malt in Feeding Cows and Bullocks. 1846.**

The proportion of these several constituents varies with every sample of barley, and in badly-dressed grain may differ widely in the several kernels of a single sample. Some chemists have examined only selected grains, others have taken samples of considerable bulk so as to arrive at a fair average. It seems that every difference in the vitality of the plant, its food supply in the soil, the conditions of development of the grain from the first fertilization of the ovule to full ripeness, and of storage in stack, barn, or bin, has its influence on the relative amounts of the several substances present. Even kiln-dried grain, stored in air-tight bins, experiences some slight changes in the course of time, as is evidenced by its ultimate loss of life, and by the alteration of the atmosphere within the bins.

Lawes and Gilbert, in their Report on the Composition of Foods in Relation to Respiration and the Feeding of Animals,[*] give partial analyses of every substance used, including six samples of barley, averaging moisture, 17·5; ash, 2·2; and nitrogen, 1·66 per cent.

W. Stein [†] and J. C. Lermer [‡] give more detailed analyses, viz.:—

	Stein.	Lermer
Starch	54·282	63·43
Cellulose	19·864	7·10
Dextrine	6·500	6·63
Fat	0·896	3·08
Extractive matter	3·556	1·11
Ash	2·421	2·40
Proteins, soluble	1·258	16·25
„ insoluble	10·938	

The fine flour of the grain consists of little but starch; the gluten layer is highly nitrogenous, and contains a considerable proportion of fatty matters; the germ is of much the same composition; the outer membranes are composed principally of cellulose, with resinous bodies and mineral salts, chiefly phosphates and sulphates of lime, magnesia and potash, with a trace of silicates.

I.—NON-NITROGENOUS SUBSTANCES.

1.—STARCH.

Starch is a generic name for a group of isomers[§] of cellulose, &c., constituting the most important part of the grain. The cells containing starch vary in form and size in every plant, and are liable to modification by the conditions of growth. Those of barley, rye, and wheat are much alike in form; and all present two categories, the large and the small cells, with none of intermediate size. In barley, the small cells predominate in number over the larger, whilst in wheat and rye the numbers are practically equal.

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[*] *Rep. Brit. Assoc.* for 1852, pp. 323—353.

[†] *Chem. Centr.*, 1860, pp. 494, 575—578.

[‡] *Polyt. Journ.* bd. clxxix. pp. 71—80 [1866].

[§] Isomers are bodies of identical (empirical) composition, but varying in properties. Thus, starch, dextrine, and woody fibre have all the same percentages of carbon, hydrogen, and oxygen, though so different in many other respects.

Size of Starch Cells (Wiesner) reduced to Inches.

	Small Cells.		Large Cells.	
	Limits.	Average.	Limits.	Average.
Barley ..	0·000063 to 0·000252	0·000181	0·000425 to 0·001291	0·000799
Rye	0·000086 to 0·000322	0·000283	0·000437 to 0·001614	0·001110
Wheat ..	0·000086 to 0·000354	0·000248	0·000567 to 0·001870	0·001453

The following figures represent some of the varieties of starch cells found in cereals:—

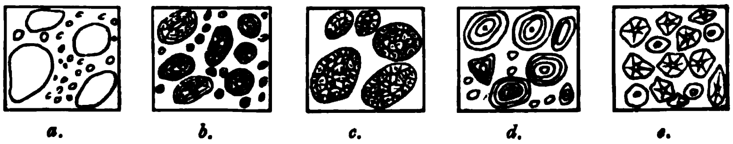

FIG. 5.—STARCH-GRANULES.

a. Barley (× 400).
b. Barley treated with chromic acid.
c. Rice (× 300).
d. Wheat (× 400).
e. Maize (× 800).

In water, cells under 0·000086 of an inch in diameter exhibit the "Brownian" movement of perpetual oscillation.

Under high powers the structure of the cell-contents is seen to be concretionary, the nucleus being more or less central in cereals, though often widely eccentric in starch of other origin, affording thereby a means of detection of adulterated flour. Radiating lines have been noticed in some cases, indicating, probably, expansion and contraction by alternating conditions during development, and the same cause has produced the vacuity sometimes present at the nucleus.

"The structure of the grains of starch is very beautifully displayed by placing some of them in contact with a drop of concentrated solution of zincic chloride (tinged with a little free iodine) on the field of the microscope. No change takes place in the granules until a little water be added. They then become of a deep-blue colour, and gradually expand; at first a frill-like plicated margin is developed around the granule; by degrees this opens out; the plications upon the granule may then be seen slowly unfolding, and may be traced in many cases into the rugæ of the frill; ultimately the granules swell to twenty or thirty times their original bulk, and present the appearance of a flaccid sac. During these changes no extrusion of anything within the granules is observed to take place."*

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* G. BUSK, *Trans. Microsc. Soc.* vol. i. pp. 59—68 [1853].

Pure starch, no matter from what source derived, is tasteless and odourless. It is fractionally lighter than cellulose, but probably varies according to the conditions of its formation. As the cell-walls do not consist of starch, crude commercial preparations of starch contain nitrogenous and fatty matters, with a saline ash amounting to about 0·4 per cent.

Though insoluble in cold water, alcohol, or ether, starch is acted upon by a solution containing two per cent. or more of alkali, forming a paste. Mixed with water at or above 140° Fahr., it absorbs it to an indefinite extent, for, by the bursting of the cells, and the dispersion of the molecules into the surrounding fluid, a jelly or paste is formed, which, though generally regarded as a solution, is not truly such, but a case of mere mechanical suspension. True solution commonly increases the limpidity of water, whilst the viscosity of paste is proverbial. Copious dilution of starch-paste causes the granules slowly to sink, leaving in solution amidin, or soluble starch. The granules do not, when dried, recover their original insolubility. Their solution is precipitated by alcohol, and the precipitate, if at once treated with water, is dissolved, but if left for a few hours becomes insoluble.

Amidin can be conveniently formed from starch by boiling it in a strong solution of zinc chloride, or of glacial acetic acid. Prolonged boiling in water only produces a mixture of amidin and dextrine. By the zinc-chloride or acetic-acid-process the formation of dextrine is avoided.

The temperature at which water begins to act on natural starch-cells varies considerably, being probably affected by their size, and by the nature of the cell walls. The hard mass produced by the drying of the paste is not again diffusible in water, however finely it may be triturated.

If starch be boiled under pressure at 300° Fahr., there is formed a thin solution which will pass through filtering paper, and upon cooling deposit a dull white powder, sparingly soluble in cold water, but readily dissolving at 158° Fahr., giving a blue colour with iodine, and precipitated by alcohol from its solution.

The action of air, or, more probably, that of the microzymes everywhere present in air, converts starch-paste by degrees into the isomeric substance, glucose. A similar change is effected by various nitrogenous matters of unstable nature, such as the remains of cell-walls, fragments of the gluten-layer or germ, the saliva (or its active albuminoid ptyalin), the secretions of the stomach and pancreas (containing pepsine and pancreatine respectively), and other similar organic matter.

Nägeli finds that ptyalin separates starch into two substances, both present throughout the starch cell. The part, which being soluble in the ptyalin solution, gives a blue colour with iodine, he terms granulose; the insoluble remainder, unaffected by or turning red with the iodine test, he calls amylo-cellulose, while Mohl prefers the designation farinose. Acid solutions produce a similar separation. The varying proportions of granulose and farinose probably affect the formation and resulting properties of starch paste.

The quasi-solution of starch is, from the presence of granulose, coloured deep-blue by the addition of iodine. On heating, the colour disappears, and, after prolonged heat, does not recur upon cooling, owing to the oxidation of the iodine to hydriodic acid. A solution of nitrite of potassium (with a trace of sulphuric acid) will reduce the iodine and restore the blue colour.

The gradual change of starch-paste into glucose, spoken of above, can be followed by this iodine test, the deep blue tint changing slowly to violet and red, all colour finally disappearing. Whether the intermediate tints be due to bodies of intermediate nature or to mixtures of altered and unconverted starch, must as yet be considered as uncertain, some authors maintaining either view.

Starch is convertible, by dilute sulphuric acid, into dextrine, and ultimately glucose, differing in this respect from cellulose, which requires concentrated acid for the same modification. With nitric acid widely different results are obtained, according to its degree of dilution. Concentrated acid dissolves the starch, and, upon the addition of water, precipitates the new compound, xyloidine, $C_{12} H_{16} (NO_2)_4 O_{10}$, which is akin to guncotton, and dangerously unstable, whilst acid, diluted before contact with the starch, oxidises it first into oxalic and subsequently to carbonic acid. If merely wetted with dilute nitric acid, and dried in thin layers at 250° Fahr., the starch is converted into dextrine.

Dry starch heated to a temperature of 320° is unchanged, but at 400° rapidly passes into dextrine. Commercial starch, which contains about 18 per cent. of water, is converted slowly into dextrine at 320°.

Starch-paste is precipitated in the cold by tannin, and though heat causes the solution of the precipitate, it reappears on cooling. The insolubility of starch in ammonia cuprate is a further point of difference from cellulose. Conversion by diastase (malt extract) yields varying proportions of dextrine and maltose, depending upon the temperatures employed, thus—

at 145° Fahr.	67·85 maltose	32·15 dextrine
„ 152° „	34·54 „	65·46 „
„ 159° „	17·40 „	82·60 „

The chemical reactions appear to consist in the combination of one molecule of water with one, two, and four molecules respectively of starch. It would seem that a fourth proportion, 50·18 maltose, 49·72 dextrine; results from the combination of three molecules of starch with one of water.[*]

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[*] O'Sullivan, *Journ. Chem. Soc.* vol. xxx. pp. 125—144 [1876]; vol. xxxv. pp. 770—785 [1879].

An ammoniacal solution of basic plumbic acetate produces in starch-paste a precipitate of the composition $C_{12} H_{18} O_9, 2 Pb O$.

Starch, heated with caustic potash and a small quantity of water, to fusion, forms a mixture of oxalate, formiate, acetate, and propionate of potassium.

From the composition of the sodium and potassium compounds with starch, Pfeiffer, Tollens, and Salomon regard the molecule as consisting of 4 ($C_6 H_{10} O_5$), with or without a molecule of water in addition. Nägeli and Sachsse, on the other hand, hold the starch molecule to be $C_{36} H_{62} O_{31} + 5 H_2 O$ or $6 (C 6 H_{10} O_5) + 6 (H_2 O)$.*

2.—CELLULOSE.

Cellulose, or woody fibre, is the name given to a group of bodies of the same empirical composition, $C_6 H_{10} O_5$, or, centesimally expressed—

Carbon	44·4444
Hydrogen	6·1728
Oxygen	49·3828

When pure it is colourless and tasteless, insoluble in water or dilute alkalies, but soluble in cuprate of ammonia, and in concentrated caustic potash, though $C_{24} H_{10} O_{20} K_2 O$ breaks up on dilution into its original constituents. Concentrated sulphuric acid forms a gelatinous quasi-solution like starch-paste, turning blue with iodine; and eventually a dextrine is produced, and, by dilution and boiling, glucose. A mixture of strong nitric and sulphuric acids converts cellulose into nitro-cellulose or gun-cotton, $C_6 H_7 (NO_2)_3 O_5$, a substitution which is reversed by alcoholic solution of potassic hydrosulphide, reproducing cellulose.

About 7·10 per cent. of barley consists of cellulose, none of which passes into the wort in brewing. Its average weight when dry is little more than half as much again as water.

As the outer wall of the starch-cells consists of cellulose, conversion of the interior by diastatic agency cannot commence till the cells be ruptured by expansion due to moisture (with or without heat).

3.—DEXTRINE (*British Gum*).

Dextrine is another group-name for a series of isomers of the foregoing class, and derives the name from the fact that (being soluble) their solution rotates a ray of polarised light to the right hand, through an angle varying with the molecular (as distinguished from the empirical) structure of the several varieties.

Dextrines are neutral tasteless substances, soluble in water, dilute alcohol, or naphtha, but insoluble in absolute alcohol or ether. They are readily changed by dilute mineral acids to sugars. Dextrine forms an intermediate stage in the conversion of starch to sugar, whether effected by mineral acids or by diastatic action.

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* *Centr. Agrik.-Chem.*, 1882, pp. 775—777.

3A.—SINISTRIN.

Kühnemann[*] maintains the presence in barley, and in imperfectly-germinated malt, of a substance isomeric[†] with, and in many points similar to, dextrine, but lævorotatory in its optical properties, whence he gives it the name of sinistrin. Being insoluble in cold water, it appears as a cloud on the cooling of its solution. Turbidity in wort and beer is attributed to this substance. Well-grown malt contains no sinistrin.

4.—SUGARS.

As the properties of the several members of this group vary to an extent slight in a chemical point of view but important in their effect on palatal and other conditions, and, as the microscope is rapidly becoming an instrument of general use with maltsters and brewers, superseding crude practical experiments, it is a fortunate thing that the solutions of different sugars rotate the ray of polarised light in opposite directions, and through angles varying with each variety. The optical and chemical phenomena, taken in conjunction, afford a much more certain diagnosis than, in the possible presence of so many isomeric bodies, chemistry alone could furnish.

As it is still a matter of much doubt as to the position, or even presence, of sugars in barley, it is unnecessary to pursue the subject further here, but some account of the several sugars will be found in my description of malt (Chap. XI.).

5.—FATS.

The fatty matters found in plants are principally stearin, palmitin, and olein, compounds of fatty acids with glycerine. By neutralising the acid (stearic, palmitic, or oleic) with alkali a soap is formed, the glycerine being entangled in its stearate or other salt. There are also many bodies of fatty nature present in plants in very small proportions, but which, being volatile, betray their presence by their odour and taste, and are termed essential oils. Most of these can be extracted by ether, and some can be obtained directly from the original source by distillation. This is the case with the so-called hordeic acid, to which the odour of fresh barley is due, and which, in the processes of germination and kiln-drying, is modified into other fats. This yields the characteristic smell of green and cured malt, and communicates flavour to the beer according to the extent of modification. A certain proportion, however, of the fat stored in the gluten-layer and in the germ, is consumed by the respiration of the embryonic plant in the earlier stages of malting, and a further portion is expelled by the heat of the kiln.

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[*] *Ber. deutsch. chem. Ges.* bd. ix. pp. 1385—1388 [1876]. This name is also given by Schmiedeberg to a new lævorotatory substance of the same formula, $C6\,H_{10}\,O_5$, obtained from squills [1879].

[†] Thausing denies this.

From 2 to 2·5 per cent. of barley consists of fatty matter. König,[*] in 1871, published analyses of many vegetable fats, not, however, indicating the proportions of the three glycerides of which they largely, if not wholly, consist. Barley-fat contains carbon 76·29, hydrogen 11·77, and oxygen 11·94. As the proportion of oxygen is higher than in even tripalmitin glyceride, there is clearly some admixture of other fatty bodies, unless some oxidation took place in the sample analysed between its extraction and the subsequent examination.

Wheat, barley, and rye contain traces of the body known as cholesterin, $C_{26}H_{44}O, H_2O$, the characteristic fat of bile, an important constituent of brain-matter, and the principal component of gall-stones. The percentage composition of this interesting substance is—carbon 80, hydrogen 11·8, oxygen 8·2.

6.—Resins, &c.

The cells of the outer coat or skin of grain develop in ripening a considerable amount of resinous matter, which, by its comparative insolubility, protects the interior from premature access of water. The steep-water removes a portion of this resin, the remainder passes, either unchanged or modified by the heat of the kiln, into the wort, and communicates its specific flavour to the finished beer or spirit.

7.—Ash.

The ash or mineral salt present in barley consists of sulphates, phosphates, and silicates of potash, soda, lime, and magnesia, with alkaline chlorides.

The percentage of ash in barley rarely exceeds three per cent., chiefly found in the husk, but present in small quantity in nearly all parts of the grain.

From evidence to be adduced subsequently, it appears that the ash is, some way, not hitherto explained, intimately connected with the nitrogenous principles of the grain, and can only be extracted for examination by the alteration or destruction of these complex bodies. It is, however, conceivable that the mineral salts are only mechanically enveloped in the albuminoid matter, and that the access of solvent fluids, whilst removing the ash, acts simultaneously on the surrounding organic substance. Nevertheless, the well-known fact that plants, and especially cereals and other grasses, require the presence in the soil of certain salts for vigorous growth if not for bare existence, points to chemical combination of organic and inorganic matter, and, though dissociation may take place in the final ripening of the grain, the presence of the salts is doubtless of great importance to the embryo in the earliest stages of germination, before the radicles commence their function of abstraction of nutriment, air, and water, from the surrounding media.

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[*] **Ueber die Elementarzusammensetzung der Pflanzenfette und die verdaulicher Fettmenge im Rauhfutter.** ***Landw. Versuchs-Stationen,*** **bd. xii. pp. 241—255.**

In their reports to Her Majesty's Government, in respect to feeding of cattle with malt (1846), Drs. T. and R. D. Thomson give the following as the average composition of the ash of barley:—

Silica	29·67
Phosphoric acid	36·80
Sulphuric acid	0·16
Chlorine	0·15
Peroxide of iron	0·83
Lime	3·23
Magnesia	4·30
Potash	16·00
Soda	8·86

Traces of alumina are not uncommon. (The analysis of the ash of the malt made from the same barley will be found on p. 146.)

Professor J. T. Way and Mr. G. H. Ogston published, in 1847—51, the results of a series of elaborate researches into the composition of the ash of various cereals and other plants used as food for man and domestic animals. Their experiments, conducted with the utmost care in the laboratory of the Royal Agricultural College at Cirencester, indicate the intimate relations subsisting between the chemical composition of soils and manures and the salts absorbed by the crops. The analyses of the ash of barley grain (on p. 109) are taken from the first and last of the series of reports, the mean of the thirteen being as follows:—

Silica	25·27
Phosphoric acid	32·05
Sulphuric acid	0·95
Carbonic acid	0·37
Lime	2·41
Magnesia	8·39
Peroxide of iron	0·76
Potash	26·30
Soda	1·22
Chloride of potassium	0·68
Chloride of sodium	1·60
	100·00
Percentage of ash	2·13

It is not asserted, nor is it probable, that the sulphuric and carbonic acids, or the peroxide of iron, exist in those forms in the grain. The sulphur and carbon, which give rise to the acids

Analyses of the Ash of the Grain of Various Barleys.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Silica	30·68	32·73	23·60	24·56	29·79	22·25	22·08	27·66	30·35	28·09	18·41	17·27	21·12
Phosphoric acid ..	28·53	31·69	26·01	28·64	25·32	37·67	38·26	37·99	30·08	32·92	38·78	30·76	29·92
Sulphuric acid ..	1·91	0·79	2·72	0·27	1·30	2·82	0·92	0·39	0·47	0·53	trace	0·26	trace
Carbonic acid ..	—	—	—	—	4·35	—	—	—	—	—	—	—	0·48
Lime	1·65	1·48	2·79	1·21	3·62	1·96	2·97	4·20	1·26	1·88	2·97	2·92	3·39
Magnesia	7·26	7·45	8·67	10·17	4·78	10·00	8·00	8·15	9·32	8·47	6·90	7·63	10·99
Peroxide of iron ..	2·13	0·51	0·09	1·02	1·54	0·87	0·84	0·93	0·24	0·10	1·46	trace	0·15
Potash	21·14	20·77	27·43	31·55	26·83	22·43	24·97	19·78	26·61	22·46	28·60	37·22	32·02
Soda	—	4·56	0·05	1·06	—	1·42	0·51	0·89	1·26	4·93	—	—	1·21
Chlor. of potassium	5·65	—	—	—	—	—	—	—	—	—	1·29	1·93	—
Chloride of sodium	1·01	—	8·60	1·47	2·47	0·56	1·44	trace	0·41	0·61	1·59	2·01	0·72
	99·96	99·98	99·96	99·94	100·00	99·98	99·99	99·99	100·00	99·99	100·00	100·00	100·00
Percentage of ash	2·14	2·25	2·43	2·12	2·03	2·30	2·15	2·03	2·31	1·79	2·07	2·13	1·99

1.* Barley from chalk soil.
2.* Chevalier Barley.
3.* Chevalier Barley, produce of No. 2 on poor soil.
4.* Moldavian Barley.
5.† Chevalier Barley.
6.† Chevalier Barley, produce of No. 5 on clay.
7.† Chevalier Barley, produce of No. 5 on sand.
8.† Moldavian Barley.
9.† Moldavian Barley, produce of No. 8 on clay.
10.† Moldavian Barley, produce of No. 8 on sand.
11.† Chevalier Barley, from loamy soil.
12.† Chevalier Barley, from chalk.
13.† Long-eared Nottingham Barley, from chalk.

* *Journ. R. Agric. Soc.* vol. vii. pp. 642—644 [1847].

† *Ibid*, vol. xi. pp. 502—506 [1851].

on calcination, doubtless form part of the albuminous principles, whilst the iron, in a ferrous state, is combined with organic acids, as are such of the other bases not in combination with silica, phosphoric acid, or chlorine.

Analyses published by Prof. Lermer* in 1866 display the composition of the ash of barley as below—

Silica	0·70760
Phosphoric acid	0·79297
Sulphuric acid...	0·01411
Chlorine	0·03336
Alumina	0·00973
Lime	0·09000
Magnesia	0·17984
Potash	0·55289
Soda	0·02578
Total in 100 parts of barley	2·40638

In the Centralblatt für Agrikultur-Chemie for 1882, p. 42, Reischauer shows, by analysis, the wide range in composition, as well as amount, of the ash of barleys from different districts, and, on p. 573 of the same volume, Moritz and Hartley give the results of their examination of the ash of certain cereals, as follows:—

	Water.	Ash.	In the Ash.			
			Phosphoric Acid.	Magnesia.	Lime.	Potash.
Barley ..	13·7	2·76	25·3—38·8	2·9—11·0	1·2 —4·2	19·8—37·2
Rice.. ..	14·04	2·34	60·2	4·25	7·2	20·2
Maize ..	14·26	1·02	53·7	18·6	0·6	28·4
Oats.. ..	16·89	3·92	14·5—29·2	5·9—8·2	1·38—8·35	13·1—24·3

In the Polytechnisches Journal for 1883, Michel and Jäckel-Handwerck give the analyses of the ash of eight sorts of barley, as follows†:—

	Hungarian.	Slavonian.	Ratisbon.	Bohemian.	Franconian.	Saal.	Moravian.	Swedish.
Silica	0·599	0·671	0·656	0·651	0·826	0·579	0·645	0·711
Phosphoric acid ..	1·010	0·790	1·078	0·923	0·798	0·817	0·804	0·767
Sulphuric acid ..	—	—	—	0·082	0·147	—	—	0·107
Lime	0·056	0·059	0·065	0·062	0·059	0·037	0·640	0·067
Magnesia	—	—	—	0·231	0·229	0·216	—	0·224
Ferric oxide ..	0·009	0·013	0·016	0·015	0·007	0·013	0·009	0·003
Potash	—	—	—	0·315	0·608	0·528	—	0·592
Total ash	2·690	2·640	2·850	2·570	2·810	2·860	2·650	2·630
Nitrogen	1·809	1·629	1·877	1·809	1·859	1·696	1·750	1·605

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* *Polyt. Journ.* bd. clxxix. pp. 71—80.

† *Polyt. Journ.* bd. ccxlvii. pp. 82—85. Abstract in *Journ. Chem. Soc.* vol. xliv. pp. 631—633 [1883].

II.—NITROGENOUS SUBSTANCES.

The nitrogenous substances found in grain are of far more complex character than those with which we have just dealt. They are not only of undefined (perhaps undefinable) composition, but are so extremely unstable as to vary even in the course of examination. They all contain carbon, hydrogen, oxygen, and nitrogen, and many also contain sulphur. From their general similarity to albumen they are termed albuminoids. By heat, after expulsion of water, they burn to a black cinder, emitting fumes of ammonia and acetic acid. Some few albuminoids are crystallizable, and of these only can it be said that their composition is known with any approach to accuracy. The non-crystallizable all retain, either mechanically and as inseparable impurities, or in true combination as essential to their existence, mineral salts derived from the organisms, animal or vegetable, in which they originated. These salts are left as ash when the cinder, formed by the expulsion of all volatile matter, is deprived of its "fixed" carbon by prolonged calcination.

All the albuminoids soluble in water are coagulated by boiling, by the addition of mineral acids or salts.

The coagula are insoluble in water, alcohol, or ether, but can be redissolved in hot dilute alkali or acid.

Albuminoids are also precipitated by tannin and by alcohol. With iodine a yellow colour is produced, which becomes red, and ultimately violet, on the addition of sugar and sulphuric acid. A red tint is also evolved by cupropotassic hydrate, or by mercurous nitrate containing free nitrous acid.

The solution of coagulated albumen made by boiling in strong hydrochloric acid is violet-red, that in nitric acid is yellow.

The chief albuminoids with which the maltster has to deal can be classified as glutens, amides, and peptones.

1.—GLUTENS.

This is a group-name for several albuminoids occurring in grain, the principal being known as albumen, caseine, fibrine, gelatine, and mucedine. Ritthausen[*] states that wheat contains all these, that maize and rye are devoid of gelatine, and the latter of mucedine also. Kreusler, the results of whose researches are embodied in Ritthausen's work, found that barley was free from gelatine, and that oats contain no fibrine or mucedine.

The abundance of gelatine in wheat, and its absence from barley, fit these grains in a very marked manner for the purposes to which they are severally devoted, the one to form a light spongy bread interspersed throughout with air-cells, the other to remain loose and incoherent in the mash-tun during extraction of its soluble constituents.

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[*] Die Eiweisskörper der Getreidearten, Hülsenfrüchte und Oelsamen. *Bonn*, 1872. But KÜHNEMANN (*Ber. deutsch. chem. Ges.* bd. ix. p. 1387 [1876]) holds that these several glutens do not occur in raw grain, but are developed by the mode of examination.

The approximate composition of the principal glutens found in grain is as follows:—

	Albumen.	Casein.	Fibrine.	Gelatine.	Mucedine.
Carbon	52·86	55	54·55	52·6	54·0
Hydrogen	7·23	7	7·27	7·3	7·0
Oxygen	22·98	23	21·48	21·1	21·3
Nitrogen	18·75	17	15·70	18·6	17·0
Sulphur	1·18	1	1·60	1·0	0·7

The average composition of the mixture of these substances, as occurring in raw grain, is sufficiently near that of albumen for that substance to represent the whole. It is not certain whether the term diastase be legitimately applicable to natural proteins, or whether their conversion into peptones be not a necessary condition of their possessing diastatic[*] power. This term (from the Greek διάστασις), denotes the power of unstable proteins to transpose the atoms of the complex molecules of the isomeric carbohydrates, and to convert insoluble into soluble matter.

The probability of molecular changes in the proteins during examination, and of the development of diastatic power consequent upon such change, renders it necessary to speak of these substances with the greatest caution against dogmatic utterance of what are necessarily little more than tentative suggestions.

Johnson[†] notes that albumen boiled with lead hydrate dissolved in dilute potash produces sulphide of lead, but boiled with potash alone (of sp. gr. 1·08) it gives no trace of sulphide on the addition of lead acetate, till concentrated potash (sp. gr. 1·3) be added. The action of dilute potash appears to consist in the formation of a tetrathionate $K_2 S_4 O_6$, whence concentrated alkali forms sulphide.

Ritthausen[‡] finds that a considerable portion of albumen dissolves in a solution of common salt; this has essentially the same composition as that dissolved by very dilute alkali.

The chief interest attaching to the albuminoids of barley lies in those which are soluble in cold water, and coagulable at temperatures below 150° Fahr. These alone possess diastatic power, the point of chief importance to the users of the resulting malt.

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[*] Some writers prefer the orthography "diastasic." The Greek verb is διαστασιάζω, "to sever"; the noun is διάστασις, "separation"; but the adjective is διαστατικός, "productive of separation." These words are used by Plato, Plutarch, and other classic authors.

[†] *Chem. News*, vol. xlvii. p. 87 [1883].

[‡] *Journ. prakt. Chem.* f. 2, bd. xxvi. pp. 504—512 [1882].

Brown and Heron[*] state that:—

"Barley, before germination, contains more soluble coagulable albuminoids than after the malting process is completed. The following table gives the results obtained by coagulating at different temperatures equal quantities of *normal* aqueous barley extract:—

100 *c.c. of Normal Barley Extract.*[†]

Temperature.		Grains of Albumen coagulated.	Percentage of the total quantity precipitated at 100° Centigrade.
Centigrade.	Fahrenheit.[‡]		
50°	[122°]	0·063	18·3
60°	[140°]	0·194	56·5
66°	[150°]	0·233	67·9
76°	[169°]	0·311	90·6
100°	[212°]	0·343	100·0

"Although the actual amount of coagulable albumen is considerably greater in barley than in malt, the percentage of the total amount precipitated at the same temperature in each case is very similar.

"The coagulable albuminoids of fresh barley-extract, although to all appearances differing but little from those of malt-extract, possess but very feeble diastatic power. Those portions which are coagulated only at temperatures above 66° C. are without action upon starch paste, whilst those precipitated at temperatures below 66° C. have a feeble action, which, however, is probably only from one-fiftieth to one-hundredth of the intensity of those existing in solution in malt-extract at the same temperature.

* * * * *

"It is possible to augment the transforming power of the comparatively inactive albuminoids of barley after their separation from the grain, and, consequently, without the aid of germination. An aqueous extract of barley, which is submitted for a few hours at a temperature of 30° C., 86° Fahr., to the action of ordinary yeast, has its power of transforming starch much increased by this treatment. A mixture of yeast and pure cane-sugar, placed under identically the same conditions, affords a liquid which does not possess the slightest action upon starch. It is evident that the growing yeast-cell is capable of inducing certain modifications in the albuminoids, which, during the ordinary process of germination, are brought about by the action of the living vegetable cell itself.

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[*] *Journ. Chem. Soc.* vol. xxxv. pp. 652, 653 [1879].

[†] Derived from fifty grains of barley by cold infusion.

[‡] Square brackets enclose additions to original.

> "This curious action appears to be confined to the saccharomyces. Whenever schizomycetes only are present in the barley extract, the infusion, far from gaining in diastatic power, rapidly loses that which it originally possessed."

Further investigations of these distinguished authors will be noticed in dealing with the composition of malt (Chap. XI.).

2.—AMIDES.

According to the most recent researches, a proportion of the nitrogenous matter in grain, varying from a tenth to a twentieth, consists of soluble, non-albuminous bodies, belonging to the widely extended class of amides * (including, probably, amido-acids, carbamides, &c.). There is also a small proportion of ammonia salts. Amides are not coagulable by boiling, and yield ammonia, by the action of acids and distillation, from magnesia.

Some of the amido-acids are precipitated by cupric hydroxide.

These compounds, as occurring in barley, have as yet been but little studied.

3.—PEPTONES.

This term (from πέπτω, I cook) implies such modification of original proteins as cooking is wont to produce. The same results may be brought about by other means than the application of artificial heat, and the differences noticeable in immature, ripe, and over-ripe grain possibly depend, in part at least, on the natural peptonisation of more or less of the protein elements. But the presence of peptones in the raw grain being so uncertain, the consideration of their composition, &c., will be more fitly deferred to a subsequent chapter, Chap. XI., which deals with the nature of malt, although some authors declare that even malt contains no peptones prior to mashing. It may be remarked, however, that peptonisation is a process of hydration, and that, by dehydrating treatment, peptones can be converted into glutens. Doubtless other molecular changes than the addition or subtraction of water take place concurrently in these operations.

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* This name has no connection with amidin (starch), but implies affinity with ammonia.

CHAPTER X.

MALT.

> " This Pandare that nigh malt for wo and routh
> Full often sayed, Alas, what may this be ? "
> CHAUCER, Troilus and Cresida, vol. ii. bk. i. p. 19.

Malt :—
Definition of Malt. Physical Indications, Essential and Non-essential. Growth. Tests. Slackness. Effects of Slackness. Age. Odour. Condition. Solubility. Tenderness. Cleanliness. Flavour. Size. Uniformity. Colour. Appearance. Weight.

HAVING considered at length all the materials used in malt making, it is necessary to describe the composition and characteristics of malt before entering into the processes of manufacture usually adopted by both civilised and savage man.

I shall thus keep to the natural and proper divisions of—I. Materials; II. Buildings and Tools; III. Processes of Manufacture.

In the opinion of many people, malt is germinated and dried barley, *solely*.

This definition is entirely delusive, for malt is *any* corn, grain, or seed, which has been artificially germinated within certain limits. In all ages, other grain than barley has been made into malt, and, quite recently, it has been clearly and practically shown that malt is made altogether independently of the process of germination. Combined heat and pressure, or gelatinisation, are now producing malt in considerable quantities from grain incapable of growth.

This fact establishes the weakness and inaccuracy of all definitions of malt which term it germinated corn, unless it be decided that any substance, to possess rightly the title of malt, must contain within itself the characteristic of germination, commonly called diastase, or, still more strictly, must be germinated barley. For the purposes of this book, the extended meaning will be accepted, so that the interesting and valuable processes of gelatinisation, &c., may be described and considered.

An immense variety of substances can be converted into malt, A considerable number of these substances can be manufactured into a variety of differing malts, distinguished chiefly by differences of colour. The tint necessarily indicates modifications in the grain other than of colour.

Thus we have—

Diastatic malt duly germinated, gelatinised, and ungerminated;
Koji rendered diastatic by mycelium, or mould;
Bousa and chica diastased by saliva.

The germinated malt may be prepared from any of the materials already enumerated, or others. I have already sufficiently regarded the minor grains, and shall now consider, chiefly, barley-malt.

The chief varieties of barley malt are as follows:—

I.—White, pale, and high-dried malt;
II.—Amber, crystal, and imperial malt;
III.—Blown, brown, and porter malt;
IV.—Black, roasted, or patent malt.

Modifications of colour are the chief commercial distinctions between malts. The one term, pale malt, may include every sort and condition of barley, from every part of the world from which it is possible to manufacture pale malt. The range may extend also from the air-dried malt that has never been, when drying, above a temperature of 90° Fahr., up to a sound malt that has been for many hours heated to 220° Fahr. upon a kiln.

The uses to which malt is put are also very varied.[*] It is still chiefly used in brewing, but it is increasingly employed in distilling, as food for men and animals, in the preparation of medicines,[†] and for many minor purposes.

Until very recently malt has been bought and sold by makers and users alike (with few exceptions) by the casual observation of its character, without resorting to a single test by means of which the judgment derived from experience could be aided.

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[*] Brande's Encyclopædia of Science and Manufacture states (p. 706) that malt is used only for making beer. It further states that the quantity of malt made in Great Britain in 1838 was 418,148,811 bushels!

[†] A paper read by Professor J. R. Uhler before the American Medical Convention in New York, mentions the following:—

" The extract of malt and hops, or glucose and dextrine, is prepared upon a large
" scale in the following manner. Malted barley is ground and placed on a
" perforated diaphragm in a mash tub, and water of 158° Fahr., or less, run on,
" thoroughly mixed, and allowed to remain for one and a-half hours. At first the
" temperature slightly rises, but afterwards falls to 154° Fahr., or less, when the
" liquor is withdrawn and concentrated in vacuo, until the saccharometer registers
" 26. Hops are now added, and after the virtues are extracted the liquor is strained
" and again concentrated in vacuo. The final step is the addition of sufficient
" glycerine to prevent fermentation, a formidable obstacle when the manufacture
" was first commenced. Medical men who have largely used it speak most
" favourably of its action; it is among the few remedies of the kind that are
" presented in the fluid or soluble condition. Its power, when properly prepared,
" to convert starch into maltose is very great, and has been proved by frequent
" experiment. In the market it is offered in various combinations, such as citrate
" of iron and quinine, glucose and dextrine, with hypophosphites, malt wine and
" iron, cod-liver oil, extract of malt, with hypophosphites of lime, etc."

Comparatively simple practical tests have gradually been adopted in transactions of magnitude, and for some years a rapidly increasing number of brewers have been trained by experts to the use of a number of accurate tests of the value of malt. The enormous influence exerted by malt upon beer has been finally appreciated by brewers. This influence has at last been recognised, and traced to the conditions of growth and storage of the grain used, and finally to such influences as temperature, humidity, and access of air exert upon malt in the first instance, then its conduct in brewing, &c., and, finally, its results in the ultimate products.

These facts point to the conclusion that further variations of the character of malt are effected by differing conditions of each of the processes through which the grain made into malt passes.

The sequence of these considerations must ultimately lead to the conclusion that, if any particular end is desired, or special character is to be communicated to beer, or any other product of malt, care will have to be taken in the primary selection of the corn, and in conducting every after-process which it undergoes.

It has been already shown how great a variety of materials can be employed in making malt. As each material can be, and usually is, affected greatly by each of the numerous processes through which it passes, it will readily be conceded that the diversity of character of malt must be indeed large.

The extent of the subject renders it necessary to divide the examination of malt into the two divisions—

I. Physical and external indications.
II. Chemical or analytical tests.

By the physical examination it is easy to determine the majority of the characteristics derivable from the barley or grain already enumerated, and also a number of the conditions induced by the processes corn passes through in course of manufacture into malt.

Barley or other corn is liable to many defects. Some of these are incapable of recognition in malt, and in addition, defects, frequently numerous, arise from ignorance and improper management in manufacture and storage. Some of them are capable of easy recognition; others baffle the skill of the wisest and most experienced, and, in our present state of comparative ignorance, are completely beyond our grasp.

The points of malt easy of determination differ but little from those of barley, although the relative importance of the essential and non-essential characteristics is curiously changed in all points excepting growth, the equivalent or outcome of vitality in barley.

Brewers may differ from me in regarding this as an essential at all, but I am writing of malt as a beer-ingredient, or wort-producer.*

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* A curious illustration of the influence of the brewers' views on this point was

LIST OF THE CHARACTERISTICS OF MALT.

Essentials :—

1. Growth.
2. Slackness.
3. Age.
4. Odour.
5. Condition.
6. Cleanliness.
7. Flavour.

Non-essentials :—

1. Size.
2. Uniformity.
3. Colour.
4. Appearance.
5. Weight.

Originally malt was valued by appearance and weight. Many appearances are deceptive, or require great judgment by experience rightly to estimate them. The actual weight of malt is even more deceptive, especially to one unaccustomed to malts made in various districts.

The whole trade suffers from the want of a universal standard for quotation. "Fine malt" at Edinburgh has not strictly the same meaning at London, Norwich, Ware, Plymouth, or Dublin. Indeed, any two separate districts have differences in value which are unexpressed. They are not, however, inexpressible; and so long ago as the commencement of this century Mr. Shannon[*] suggested a very excellent plan which, if adopted, would have given much more fixed value to the market terms now in use. So soon as the saccharometer was practically used by brewers the opportunity of employing some set phrase was offered. Shannon suggested the word *par*, which should be the equivalent of the term "proof" in spirit and wine transactions, fixing *par* at 80 lb. extract per quarter. Any sample of malt that would yield 84 lb. would be four above *par*, or if the extract yielded were 75 lb., then it would be termed five below *par*, and so on.

Theoretically this is an excellent suggestion, but in practice it has never been adopted. Maltsters so rarely know how to estimate the extract value of any sample of malt, that it would be impossible for them to speak of the true grade of their malt as either above or below *par*. They find by experience that they cannot invariably rely upon the statements of amount of extract made to them by consumers.

A still greater difficulty lies in the fact that the extractive

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furnished in the original compilation of the following list. After much reference and reflection I wrote it, and placed the qualities, as I thought of them, in the following order :—Size, weight, uniformity, colour, appearance, odour, condition, growth, slackness, age, cleanliness, flavour. I thus put all the non-essentials first, and only by logical analysis were they afterwards arranged in proper order. Many other practical brewers and buyers of malt might probably do the same.

[*] A Practical Treatise on Brewing, Distilling, &c., p. 166.

value of malt is not the only test or gauge of its intrinsic or commercial value.

Malt materially differs from country or British barley in respect to samples. Farmers usually take samples of one unmixed growth which is comparatively uniform. Any heap of malt in an ordinary malthouse is necessarily of a more mixed character even than the barley from which it has been made; for the variations of temperature, air-supply, and humidity of air are, in the vast bulk of malthouses, beyond control, and these conditions necessarily affect to a considerable extent the character of every floor of malt made, and cause variations in one bulk, or growth of barley.

To take a sample of malt, therefore, it is very desirable to procure an equal quantity from as many points as possible of a heap or bin. The sample when drawn, if not immediately used or tested, should be kept in a tight tin, or stoppered bottle, and all air absolutely excluded. As the moisture-percentage is one of the most important factors of value, and malt is remarkably hygroscopic, any sample kept in a bag, or otherwise exposed to the air, if only for a few hours, is no longer a fair sample of the bulk.

This is true of all descriptions of malt, but especially so of crystal malt, which is extremely affected by slackness. If it be allowed to remain exposed to air for any considerable period prior to grinding, it will bind in a complete mass, of tenacious leather-like consistence, upon the rolls, rendering it impossible to drive the mill.

The characteristics of malt are incapable of such clear definition, or division, as those of barley. In some respects they are much simplified, but in others the influences of the complex processes of malting have to be duly considered. These are, however, the most difficult to estimate; for the most searching analysis, and the practical test of the forcing tray, are not always capable of determining the true composition or character of the malt.

The tests of the chemist during the full examination in the laboratory are chiefly to determine the following points:—

The yield or percentage of extractive matter.

The nature or composition of such extract. (The actual yield and, roughly, its commercial value, are comparatively easy of determination.)

The nature and composition of the wort yielded by malt are extremely difficult to determine.

The patient and arduous examinations of many distinguished brewers and chemists have thrown very much light upon the subject, but all that is known leaves still much to be discovered, and proved. Our own countrymen, Messrs. O'Sullivan, F.R.S., Brown, and Heron, have taken a very high and honourable position in this abstruse subject, and many foreign names have become familiar to English brewers in association with it. Still, those who know most about it are most willing to admit how imperfect all our knowledge is, and how much remains to be learned.

This may be taking the subject into the brewers' province, but a maltster who cannot thus follow it, is defectively trained. The maltster should regulate his proceedings in the malthouse under the guidance of the brewer if incompetent to settle any point or practice for himself.

I.—PHYSICAL EXAMINATION OF MALT.

Essential Characteristics of Good Malt.

GROWTH.—As vitality in barley is the characteristic of greatest value to the maltster, the growth of malt is also the main factor in considering its positive and comparative values.

The word growth has a wider signification than vitality; for, although no barley can possibly possess too much vitality, malt which is grown too much is of greatly reduced value.

Corn which is irregularly grown, or has the acrospire very imperfectly developed, is not good malt.

Any corn which remains ungerminated is not malt at all (unless it be gelatinised), for the conversion of a barley corn into malt is indicated clearly by the degree of development of the acrospire, and in ungerminated corn the acrospire is dormant. This degree of growth is commonly spoken of as the length a corn is backed—*i.e.*, the growth of the acrospire, or plumule, up the back of the kernel.

The paramount importance of growth is consequently obvious. It is, perhaps, rare to find brewers who subject malt to close and careful scrutiny prior to its purchase. It, however, pays well to devote attention to the subject. The following tables indicate the differences which exist in malt. They are compiled with a view of illustrating the growth of malt, and are not intended to be used, even remotely, to serve as any basis for comparison of localities, or class-qualities.

A very great deal of light may be thrown upon the value of a sample by its analysis, as indicated in the following tables. All that is needed is a little patience, and the labour is well repaid by the knowledge gained.

	Norfolk.	Essex.	Scotch.	Dorset.	Saal.	Danubian.	Chilian.
Perfectly grown big corn ..	64	57	59	54	40	21	67
Perfectly grown medium-sized corn	17	12	14	17	32	19	2
Perfectly grown small corn ..	5	7	2	5	18	11	—
Imperfectly grown big corn ..	2	1	6	2	—	—	26
Imperfectly grown medium corn	7	9	13	11	2	17	5
Imperfectly grown small corn..	5	14	6	11	8	32	—
	100	100	100	100	100	100	100

Of the perfectly grown corn the true bulk-percentages were—

	Norfolk.	Essex.	Scotch.	Dorset.	Saal.	Danubian	Chilian.
Acrospire, seven-eighths up back	67	41	7	39	19	10	66
,, over one-half ,,	19	35	58	37	71	41	3
Imperfectly grown corn—							
Acrospire run out	9	2	—	2	3	—	8
,, less than ½ up back	—	6	16	18	—	42	12
Ungrown (dead)	—	3	11	—	1	1	6
Damaged as barley	1	4	3	2	6	3	1
,, in malting	2	2	5	1	—	1	3
,, by insects	2	—	—	1	—	2	1
	100	100	100	100	100	100	100
Percentage of mouldy corns ..	9	12	24	4	7	5	3
Friable malt	94	82	16	91	64	56	90
Hard-ended and vitreous malt	4	3	47	2	35	41	9

To determine percentages of growth with accuracy (as above), it is necessary to take the average of several different countings of at least 600 grains in all.

A very common but unreliable test of the growth of a sample commends itself for its simplicity and convenience. A fixed number, commonly 100, of malt corns is counted. These are placed in a glass, and cold water is poured upon them, or they are thrown into a glass of water, and stirred to ensure uniformity of wetting, and prevent the keeping up, by the adhesion of air-globules, corns that would sink. The malt is by this means graded into four qualities :

I. Those that float at the surface horizontally.

II. Those that float at the surface with one end more or less depressed.

III. Those that sink to the bottom.

IV. Those that sink to the bottom lying flat, but stand more or less on one end.

Upon examination, it will be found that all of Class I. are good, well grown, malt corns. II. may or may not be a little hard or unmalted at the depressed end. This, however, is somewhat ruled by the age and storage of the malt, for if a sample be tested shortly after leaving the kiln ; and again six weeks afterwards, it will be found that the indications vary widely, particularly if the malt has been properly stored and sweated. All corns in Grade III. are germinated comparatively slightly, whilst those in Grade IV. have very generally germinated but little, or have been altogether idle.

This test is frequently used, probably more than any other, but if the mere counting and casual inspection of the corn only be practised, without close and critical examination of the plumules of the sunken corns, it is very frequently misleading.

The chief reasons why growth in malt is of such importance are revealed by its chemical examination, when it is found that germination induces in all cereals changes of a most marked and complex character. As a fact, the whole of the soluble constituents of the grain are virtually rearranged. These changes are in themselves considerable, but they become much intensified or more powerful by the aid of diastase, when malt is infused at certain easily and frequently-attained temperatures.

The great evil of ungerminated corn is that, in addition to its loss of the benefits of growth, it suffers from a very general tendency to decay, and also to encourage mould during malting. Each dead, broken, or damaged corn becomes a centre of contagion, upon which a vast number of mould-plants and other low organisms fasten, and then distribute their germs, spores, or microbes, to all other grain in contact with them.

SLACKNESS.—Few things are more easily determined than the percentage of moisture in malt. No other characteristic influences its value more completely. Yet not one per cent. of the malt made has ever proper attention paid to it to prevent it becoming slack; nor does even so large a proportion of the maltsters of Britain know how much water they sell, or of the brewers how much water they buy, in malt.

The slacker malt is, or, in other words, the more water it contains, the smaller will be the total extract it affords, and the less value will the extract possess, for no malt can absorb any moisture and remain unaffected detrimentally by it.

When this fact is accepted and understood, the removal of malt in sacks by rail or sea in our humid climate will be abolished, and maltings at great distances from the brewery will be abandoned.

In an American brewing paper of repute, quite recently, it was gravely stated as an absolute necessity to sprinkle two to three per cent., by weight, of water upon the malt twenty-four hours before use, turning it several times to ensure regular absorption. The object was to ensure tap-running without difficulties.

It is currently believed that re-drying slack malt makes it as fit for use as sound malt well dried. If when slack it could be demonstrated that the moisture present (evidenced by the slackness) did not influence badly the albuminous matters, it might then be proved that slack malt redried was not a damaged article. It does not appear reasonable to expect this; and, practically, such malt can be redried as thoroughly as possible, but the influences of the slackness can be detected during mashing, fermenting, and storing, with absolute certainty.

The power of all malt to absorb moisture is very great. The main cause is probably the hygroscopic character of the saccharine, albuminoid, and colouring principles. This appears to be evidenced by the fact that brown, crystal, and patent malts become much more easily clung or slack.

Malt of any kind is permanently injured by the absorption of moisture before it is perceptibly slack, and the ordinary test of slackness by biting individual grains is inadequate and unreliable.

The methods adopted to prevent this evil are explained in Chapter XXI.

In addition to, and perhaps concurrently with, the evils of slackness already described, the great power of moisture to aid the spread and development of mould is insufficiently considered by maltsters. Despite every care, it is frequently impossible to keep growing malt free from mould. It has been proved experimentally that mould-spores retain their vitality for years, after undergoing the highest temperatures malt is subjected to. So long as the malt remains dry these spores continue dormant; but the absorption of a small percentage of moisture furnishes them with the final necessary condition for development and reproduction. Slack malt is, accordingly, very generally more or less mouldy.

AGE.—The age of malt has never been sufficiently considered by maltsters, brewers, or, indeed, any other users. The cause for this has, doubtless, been the apparently inevitable necessity to use malt of widely varying age. Few brewers like to use malt stored for a less period than six weeks. They unhesitatingly use it after many months' storage, commonly betraying entire indifference as to the nature of the store, or the influences of air or heat brought to bear throughout the time.

Yet the readiness with which wort breaks or clears in the copper when boiling, is largely ruled by the age of the malt mashed. Turbid, badly-separating, stubborn, and opalescent beer is generally produced from the malt used being too young or new. Very old malt, or indeed anything over four months old, is commonly slack. Even if it be not, it suffers in odour and condition. There is, unfortunately, no reliable test for age; nor are the differences in appearance of old and new malts such that they can be described verbally.

Pneumatic maltings render altogether needless and unnecessary the use of any malt differing in age more than a very few weeks. Barley may be stored for many months without material injury, but malt cannot be so. As pneumatic maltings can work all the year round, the supply of new malt can be regulated entirely by the quantity consumed, and the reserve of corn is best retained unmalted.

ODOUR.—The odour of malt is important in determining, to some extent, the manner of making and storing. Good malt has a pleasant well-known aroma special to itself. In examining a sample, it is always advisable critically to smell the unbroken malt, and then in a small ivory or hard-wood pestle and mortar (Fig. 100) to crush a few grains thoroughly, and detect the aroma thrown off. This is sometimes faint and unpleasant. If so, the malt is unfit for use. If the scent be fresh, strong, and good, it indicates proper attention to drying in the kiln, and the malt may be safely used.

Odour is almost entirely ruled by drying and storage. Should any mould exist, a good olfactory organ can detect it at once.

CONDITION.—The term condition has to be expressive of a variety of qualities of malt. It embraces quality of barley, solubility, tenderness, friability, glassiness, &c. No strict line of demarcation can be drawn in the definition of condition; for some of the characteristics commonly attributed to it are more conveniently classed under colour, odour, flavour, appearance, age, slackness, &c., &c.

Quality of Barley.—The general condition of malt is about equally affected by the mode of making, condition of storage, and quality of the barley used. Good barley, but badly managed and worked, often produces inferior malt. Barley out of condition, or inferior in a variety of ways, is very frequently made by skilful maltsters into useful malt. In very rare cases, however, is any positive evil in barley eradicated. At best, it is but coloured over or hidden. In consideration of size, weight, colour, appearance, odour, flavour, and growth, it is always necessary to remember this, and make such allowances as each particular case demands. Experience alone can teach how to do this.

Solubility.—The solubility of malt merits more attention than it receives. The character of the barley and the malting processes alike affect this. Coarse, thick-skinned, big barley, from heavy soils, will frequently make malt which is comparatively insoluble, especially if coarsely ground, and mashed with hard water at high temperatures.

Tenderness, Friability, Glassiness.—These opposite characteristics of malt formerly held a very prominent place in the determination of values. Good malt was always expected to be tender and friable. If bitten, it should be crisp and crumble readily under the teeth, and should, if drawn across a black board, leave a mark white and clear as soft chalk. The term cretaceous was frequently applied to it.

Bad or inferior malt was frequently glassy, or vitreous, and all vitrified malt was naturally regarded as decidedly inferior. Now that brewers have acquired wide experience in the use of raw grain, tenderness is less important than before.

The causes of hardened or vitreous malt are, generally, imperfect growth, or irrational drying. In both cases the evil is of material importance. If malt is purchased, it ought to influence price more largely than it does. If a brewer makes it for himself, it indicates a great degree of carelessness or ignorance of a serious kind. The tests for glassiness are simply biting and floating in water, as in test for growth. The water test is the more reliable, as imperfectly-grown corns are almost always steely and bad, but steely malt which is grown well is not always inferior. Some Algerian and Danubian, or other hot-climate barleys, make apparently flinty malts, which give very good results when brewed. Malt which is vitrified upon kiln, by raising the heat too rapidly at the earlier stages of drying, is considerably damaged. When corns that have grown well are flinty, it is generally the result of bad drying.

CLEANLINESS.—When maltsters paid duty, they very generally screened all barley prior to steeping, with the object of removing the thin corn and dirt, upon which it was, of course, absurd to pay a duty which amounted to over a pound sterling per quarter of eight bushels. As a consequence, malt was commonly supposed to be clean. Many maltsters now steep barley just as they receive it, simply to save the expense of screening.

Such false economy, negligence, or laziness, cannot be too strongly deprecated; for it never happens that a quantity of barley is delivered in such a state that it cannot be very materially improved by the removal from it of a quantity of dirt, dust, other seeds, and refuse of infinite variety. I have never yet seen a sample entirely free from thin corn (the evil of which is shown subsequently). As a rule, all barley is mixed with a diversity of rubbish of a distinctly detrimental character, and as in many cases it is not removed, it naturally follows that all the evils are present in the malt made from it.

Further than this, nearly all malt gathers in manufacture and storage an accumulation of dust, dirt, and refuse of a very objectionable character. The rootlets naturally produced by the process are detrimental, and, if present, interfere with the cleanliness of a sample. Malt very usually contracts more or less mould during manufacture, and invariably gets adhering to it the spores, or germs of a number of low organisms, of an undesirable and dangerous character. These occur in all malthouses, at all seasons; for the conditions necessary to produce malt, necessarily favour the production of mould, and, as all barley contains some kernels dead, bruised, or broken, and kept in a moist condition for many days, the rapid diffusion of mould spores is inevitable.

Close inspection and microscopic examination of malt are necessary to determine its degree of cleanliness.

Inspection is greatly facilitated if the sample be weighed first of all with accuracy. Then it should be passed through a sieve of sufficiently coarse mesh to allow the malt to pass, but to arrest any substance larger than a barleycorn. It should then be sifted in a sieve with finer mesh, that at once removes the heavier dust, dirt, &c. The malt should then be placed upon a sheet of clean white paper, and every kernel passed under scrutiny. A broad round-ended knife or paper-cutter assists this operation. A number of the corns should then be magnified, and particular care taken to examine the ends and crack, for the mould-spores generally lodge in those positions. The whole of the matter which is not malt can now be weighed, and its percentage determined. By these methods I have found the following results :—

Source of Barley.				Percentage of impurity by weight.		
Norfolk,	containing	by weight	from	0·2	to	2·4
Essex	,,	,,	,,	0·3	,,	2·7
Lincoln	,,	,,	,,	0·5	,,	0·3
Scotland	,,	,,	,,	1·2	,,	4·1
Ireland	,,	,,	,,	0·8	,,	3·1
Chili	,,	,,	,,	0·1	,,	6·8
"Danube"	,,	,,	,,	2·4	,,	4·7
Saal	,,	,,	,,	0·9	,,	3·4
Russia	,,	,,	,,	1·6	,,	5·4
Bohemia	,,	,,	,,	0·2	,,	2·4

Malt always contains in bulk a large quantity of metallic refuse, but in the above table no metal has been included. The heavy percentages of refuse are of course exceptional in nearly every case.

FLAVOUR.—Malt has invariably a considerable amount of flavour. Popularly it is supposed to have the starch of the corn largely converted into sugar, in consequence, presumably, of its apparent sweetness. No analysis, carefully taken, confirms this supposition.

The flavour of malt is derived either from the influences of growth, or drying; generally from both combined. Air-dried malt or that dried in a kiln at too low a temperature, or out of the direct contact of the products of combustion, has a raw, harsh, unpleasant taste.

Pale malt, dried in an open fire-kiln at as high a temperature as possible without interference with the colour, has a brisk agreeable flavour, much liked by cattle and children. This flavour is communicated to the beer, spirits, bread, or other articles made from the malt, and for many purposes constitutes one of its chief virtues. It furnishes a very clear indication of the manner of curing the malt, and consequent stability of the beer brewed from it.

Brown, imperial, amber, crystal, and other similar malts are manufactured chiefly for the sake of the flavour which they acquire by different methods of drying, and which, together with colour, they communicate to the beer or porter they produce.

Patent, black, or roasted malt is intended primarily to give colour to beer or porter, but it adds flavour also.

Freshly dried black malt has a bitter astringent flavour, which is extracted by boiling. Wort from black malt closely resembles strong coffee in flavour.

Kernels of pale malt attacked by mould have a rank, nauseous flavour which is very disagreeable.

The flavour of malt is usually determined by biting a few corns. It is best tested by making a weak infusion at high temperature, and allowing it to stand for a few hours after it has cooled.

Inattention to any of the preceding seven characteristics of malt is unwise, and may be attended with disastrous results.

No truly good malt can be deficient in any respect in any of the points indicated as essential.

Of the remaining characteristics, although each one is desirable and beneficial in its way, really good malt can be produced though one, or indeed all, are absent.

Small, light, irregular malt of indifferent appearance and colour will produce better beer, provided it has each of the essential characters well and fully developed, than the largest and most beautiful looking malt if decidedly deficient in any essential point.

Hence I term size, uniformity, colour, appearance, and weight desirable non-essentials.

II.—Desirable but Non-essential Characteristics of Good Malt.

Size.—The size of malt has received very great attention at the hands of many writers upon malting, and has been the cause of much consideration and calculation. Large malt is better than small, all other conditions being equal. Small malt, perfect in all essential points, is better than big malt deficient in any one of the characteristics I have termed essential.

The size of malt naturally depends, in most cases, upon the size of the barley from which it is made. It is, however, in many cases very materially influenced by the method of making. By particular management upon the kiln it is very easy to dry malt in such a manner that the size is much affected. As a consequence, proper consideration of size is possible only by comparison with weight, number, and bulk. Lengthened experience is of much benefit, but reliance upon it is at times misplaced. Size is conveniently determined by any fixed measure or standard of capacity in which a certain quantity of malt, under similar conditions of pressure, may be placed, and the differences in number decide the relative size.

Of two bulks of malt of the same size, preference should be given to the heavier, provided they both contain the same percentage of idle corns and the acrospires of both have been equally worked.

One important factor of size is the shape of individual kernels. Short, round, plump corns necessarily yield a greater extract than long thin corns of the same size and weight.

The proportion of husk to soluble constituents is larger in the latter case. As a consequence, 100 long thin corns occupying the same cubical space, and weighing the same as 100 other short, plump corns, will be found to yield less extract when brewed than the plump corns.

Uniformity.—By uniformity is meant not only such similarity as can be attained by working barleys, alike in their essential properties, but the much more powerful elements of sameness that are controlled by the conditions of the air, and its management throughout every process of malting.

Large firms secure a considerable degree of uniformity in malt by careful selection and mixture of barley. This point is an important one, but it is only one factor of several, and as a practice can have strong objections urged against it.

Uniformity of size is of importance to the brewer. This is the one phase of the subject easily determined. The eye is usually a sufficient guide as to uniformity of kernels.

At present no reliable tests have been invented as to uniformity of conditions during each and every process of malting.

The uniformity of growth is easily determined by counting one or more hundreds of kernels, and taking up each one in turn, placing it in with others of the same length of acrospire.

The following typical illustrations, giving percentages of growth, show the value of uniformity in samples by careful examination. (See also Growth, p. 120.)

Percentages of Growth.

	Good Malt.		Medium Malt.		Bad Malt.	
Acrospire run out	—	1	3	—	12	26
,, ⅞ up back	9	4	7	4	19	21
,, ¾ ,, ...	64	80	64	79	42	28
,, ½ ,, ...	26	9	14	11	17	9
,, ⅜ ,, ...	1	3	6	—	—	1
,, started	—	1	3	2	2	—
Dead corns	—	2	3	4	8	15
	100	100	100	100	100	100

Much wider differences than these are to be found in malts constantly offered for sale.

COLOUR.—The colour of malt varies from that of barley, and colour is not a certain criterion of the treatment the malt has undergone, in any or all the processes it passes through. Bright pale barley may be stained and discoloured in cisterns or on floors and kilns. Bad management during any stage of working, but particularly during drying, will affect the colour of malt, as usually understood, and also the colour of the wort produced by malt. Drying prolonged beyond a proper time, or excessive temperatures at any of the stages upon the kiln, particularly when the malt is still moist, affect the colour of the interior of the corn to a greater extent than the colour of the skin.

If the interior of the kernel be discoloured by heat, or rendered brown, part of the diastase and of the albuminous matters have been destroyed or injured in such drying.

The question of the importance of colour has been already hinted at. In pale worts from pale low-dried malt the degeneration of yeast is usually rapid. In higher-dried malts, all other conditions being similar, it is much slower. How far the colour influences this, remains to be determined, but it is a point worthy of attention not only of brewers, but of maltsters.

To determine colour in examination of any particular sample of malt it is desirable to hold it at arm's length in a good clear light, but not in direct sun-rays. A north light is most esteemed for this purpose. Under these conditions a good sample will be a good clear yellow in tint, free from all stain or shade of mottled grey or brown.

Examination of the rootlets left in a sample furnishes a good indication of the degree of colour given by drying. Owing, however, to the wide differences of heat found in nearly all kilns, this method is very unreliable, for the variation of colour of roots is greater than that of the malt, and is very deceptive. Great heat at the end of the drying process will darken the combes, but not the malt to the same degree.

Another plan is to masticate a few kernels, and then compressing the mass between the thumb and forefinger to judge of the colour of the moisture exuded.

The best and only reliable test of colour is to make an infusion at given and exact temperatures and gravity, for a certain length of time. This should be compared with a standard test tube of exact shade.

To colour is usually accorded the distinction of the chief market differences of malt, for it is graded almost exclusively with regard to colour. Thus we have the four main divisions into which the eight common varieties of malt are divided:—

I. White, pale, and high dried.
II. Amber, crystal, and imperial.
III. Blown, brown, or porter malt.
IV. Black, or patent malt, and roasted maize.

White malt is usually made from very pale and superior barleys, worked with great care, and dried at the lowest possible temperatures. Comparatively little is made.

Pale malt is the class made in greatest amount, and, unless otherwise indicated, is the class invariably alluded to and described throughout this book.

High-dried is generally the same as pale, made from inferior barleys, or from barleys which may have derived damage in any form. As its name indicates, it is more highly dried than pale malt, and is as a consequence darker in appearance, and yields a wort of darker tint.

Amber malt is also made from spoiled pale malt, or from barleys rarely of equal quality to the best pale malt. No standard test of colour has yet been determined upon. Amber is usually darker than high-dried.

Crystal malt is still darker. It owes its characteristics to peculiarities of manufacture to be afterwards described.

It is valued also for its flavour.

Imperial is lighter in tint than crystal, but it gives a better colour and flavour for particular purposes.

Blown, brown, or porter malt, is also differently prepared. Its use is an absurdity fast dying out. It is inferior in colouring power to either amber, crystal, or imperial malts.

Black or patent malt, and roasted maize, are used almost exclusively for colouring purposes. Owing to the manner of their preparation, a very great proportion of their extractive matter is converted into caramel or assamar, and as a consequence they yield very little but colour and flavour.

It is much to be regretted that no standard of colour has been decided upon to determine the relative values of samples for colouring purposes. Each maker or user of malt can, however, prepare a standard for himself, and in no case should he buy or sell any quantity of malt of which he has not fully determined the colouring value. This is simply, easily, and quickly done.

Were this a book on brewing, this division would require much more exhaustive treatment, for there can be little doubt but that the examination and comparison of colour in relation to its effects upon fulness of beer, extract of malt, and the nourishing capacity of wort, is of very great importance.

It may be some day proved that by relation of colour-values the whole influences upon yeast-nourishment of worts may be determined.

APPEARANCE.—The appearance of malt not already considered under colour, size, uniformity, and cleanliness, is of slight moment. A sample may be dull, dead, and heavy-looking, or it may be very starved and shrivelled.

The appearances indicative of good or bad qualities not already enumerated are too subtle to be conveyed by words, and practical experience is alone of value in connection with them. To the general appearance I attach more importance than to weight, which I put in its right place, last on the list.

WEIGHT.—Old maltsters usually attached great value to weight. I have already shown that in barley, weight is not of paramount importance. In malt it is positively a dangerous test in the hands of the unwary or inexperienced. Formerly 40 lbs. per bushel was considered a good weight for malt. Owing to the careful cultivation of barley, it is now no unusual thing to find well-grown and properly made malt weighing 44 lbs. per bushel. Such big malt gives a greater extract, in consequence of the smaller amount of husk contained in proportion to soluble constituents, and the quality of the extract obtained is much esteemed. This is more particularly the case in those breweries where they do not know how to grind their malt properly, or are afraid to do it.

As a brewer's question, weight is of considerable importance. A maltster, however, ought never to consider it. Barley should be worked in the best manner possible, quite independently of any consideration of its final weight as malt. No malt should be bought by weight unless due consideration be given to the actual weight of the dry substance of the barley from which it is made. This weight is known in extremely few cases, for although the number of brewers who take the trouble to determine the percentages of solid matter and moisture in malt is small, the number of maltsters who test barley in the same way is much less.

The true value of weight in malt is readily tested by taking a diversity of samples, and selecting them as indicated in the tables on growth. It very frequently happens that the heaviest malt is shown to be inferior in several ways to lighter malt.

By the physical examination of malt, we gather that good well-made first-class malt should be wholly and well-grown, with a properly developed acrospire at least three-quarters of the way up the back of the corn, but never grown out.

It must be properly dry, containing never more than two per cent. of water.

It must be at least six weeks old, but never older than four months unless kept in air-tight bins, or plunged in carbonic acid gas.

The aroma must be pleasant and well-distinguished.

It must be friable, tender, white-floured, and in good condition in every respect.

It must be clean, and free from admixture with other cornseed, or particles of any kind.

It is desirable to have it large, or of good size; but whatever size it may be, it should be uniform.

The colour is a matter that in most cases is worthy of consideration.

The appearance generally should not be neglected, for mould is a more powerful evil than is generally admitted.

Weight requires also intelligent and careful regard.

To users of malt, however, it is of the utmost importance to know other things concerning it not able to be determined by any amount of experience, or by the tests already described or suggested. A good deal has been done by the aid of chemists, and we will now pass to the chemical examination of malt.

CHAPTER XI.

MALT (*continued*).

Malt:—
Chemical Examination. Losses of Barley in Malting. Molecular Composition. Analyses. Starch. Cellulose. Dextrine. Sugars: Maltose, Sucrose, Glucose, Lævulose. Fats. Resin. Ash. Proteins: Diastase, Amides, Peptones, Parapeptones. Acidity: Lactic, Butyric, Acetic, Succinic Acids. Tests.

CHEMICAL EXAMINATION OF MALT.

I HAVE already shown that the chemical examination of malt is necessary to determine the yield or percentage of extractive matter, and the nature of its composition. The senses alone are incapable of settling these and several other points.

Because brewers rely largely upon the mere appearance and taste of malt, and are willing to assign bad or defective beer to any other agency than the malt used in its preparation, maltsters have worked in the crudest and most imperfect manner. They have, as a body, made malt in utter ignorance of the simplest conditions of the business, and of the laws regulating the effects of the processes they imagined that they were controlling.

British maltsters were, indeed, rare (until very recently) who were capable of intelligently comprehending the influences upon barley of differing degrees of moisture, access of air, conditions of heat, or, indeed, the very simplest of the forces they put into motion in the conversion of barley into malt.

Happily this state of things is passing rapidly away, and it is now recognised as important for a maltster to know what malt is, in order that he may control, or regulate, every process which improves or mars the desired product.

The changes effected in barley by the processes of germination, consist in the removal of some portions of the constituent molecules, and the modification of many, if not all, of those which remain.

The absolute loss barley sustains when malted ranges from 19 to 24 per cent., by weight, and is chiefly water, but there is also a loss of solid matter, which, however, is fully compensated by the beneficial changes effected in the remainder.

The loss occurs in five ways, viz.:—

1. Floating corns skimmed off the cistern.
2. Loss by solution in steeping.
3. Loss by respiration of the germinating grain, in the formation of carbonic acid gas and water.
4. Loss of original moisture, beside that of added and of newly formed water.
5. Loss of rootlets (combes) in screening.

These several items of loss vary with every difference in the grain subjected to malting, in the water used in steeping, and in the duration, temperatures, air-supply, &c., on the growing-floors and kiln. A rough average gives the following amounts of the several losses:—

	Per cent.
Floaters	1·5
Loss in steep	1·5
Respiration	6·0
Water	11·0
Combes	3·5
	23·5

The proportion of floaters depends partly upon the quality of the grain, but mainly upon the methods of screening adopted. Where this operation is properly performed, the percentage of skimmings falls to a minimum.

The loss in steeping is not apparent, being concealed by the great absorption of water, and consequent gain, both in bulk and weight, of the saturated grain. But analysis indicates a loss of from one to two per cent. of solid matter, and the presence of extracted substances in the steep-liquor is also demonstrable. The offensive odour of the liquor, where not changed at intervals or continuously, during the steeping period, is partly due to the substances dissolved from the grain, but the putrefaction of these is mainly, if not entirely, due to the dirt adhering to the husk, in spite of the most thorough system of brushing, screening, and washing the barley prior to steeping. This dirt contains living germs of various fungoid and other organisms, which develope under the favourable conditions offered by the steeping-cistern, and convert any unstable substances present in the liquor into acids and alcohols of offensive nature.

We have here a powerful argument both for frequent, if not continuous, change of steep-liquor, and against the proposal made by some authors to furnish the grain with only as much water as it can absorb. In that case, none of the germs of mould, &c., could be drowned or derive sustenance from waste matter, but all would develope and feed upon the grain, passing with it to the growing-floors.

The presence of nitrates in the steeping-liquor promotes these objectionable developments as much as it favours the germination of the grain, but salts of lime, by preventing acidity, retard the extraction of phosphates from the barley, thus at once retaining those important compounds for the function of nourishing the rootlets, and, at a later stage, the yeast-cells, and depriving the mould-germs of nutriment to the same extent.

The character, as well as the amount, of matter dissolved and lost in steeping, varies with the composition of the water used, with the quantity of resin-cells in the husk (which constitute a damp-resisting varnish), and with differences in the rapidity with which the organic compounds, including mineral matter, decompose or become soluble.

The wide variation in these factors fully accounts for the discrepancies in the amount of loss in steep given by different authors. Maltsters generally use the most convenient source of water supply, regardless of its character, whilst the variable elements of the barley referred to depend greatly upon meteorological conditions during ripening, and upon judicious harvesting and storage.

I shall return to this subject in the next chapter.

The loss in germination depends upon a still wider range of contingencies, the vitality, permeability, and chemical composition of the grain, the temperatures, degrees of humidity, duration and extent of growth, and other important factors determining the resultant amounts of carbonic acid gas and watery vapour given off, and the character of the changes induced upon the remaining matter.

The loss in drying, again, varies with the proportion of moisture present in the green malt, and with the structure and management of the kiln. Excellent green malt may be spoilt even under the most skilful working upon an improperly-constructed kiln, whilst the most perfect structure will not obviate the results of errors in previous operations, or of mismanagement of the drying process.

The loss in combes depends upon their development, including any forcing of the acrospire by deep loading upon the kiln, and consequent stimulus of vegetative power by the warm damp air which bathes the upper part of the load.

With imperfect drying, a greater weight of combes results from the presence of moisture in them, but as a similar residue is left in the malt, there is, on the bulk, a less loss of weight than if the drying were thorough.

The changes induced in grain by germination (as apart from the removal of matter) are chiefly the conversion of the carbohydrates on the one hand, and the protein-compounds on the other, into isomers, hydrates, or derivatives, of inferior stability, so that they readily pass, in after-treatment, to the more stable compounds required in beer and other products. The previously insoluble starch, for instance, is to a great extent brought into a form from which its change into dextrine and maltose under diastatic, and subsequently to alcohol under zymotic, influences, will take place with ease, and without the formation of collateral products of an undesirable character.

Still more important are the modifications which occur in the structure, composition, and chemical powers of the protein-compounds. Not only is the instability of their complex molecules of the greatest value in its influence on the adjacent carbohydrates, converting them during the processes of brewing, &c., into fermentable and other substances, but the proteins which pass forward into solution are, under favourable circumstances, such as either yield to the decomposing vital forces of yeast, or remain unaltered in the finished beer. Those proteins which are changed into yeast and vapour have fulfilled their function in promoting the fermentation essential to the stability of the liquor, whilst the remainder contribute to its nutritive qualities. On the other hand, unsuitable proteins lead to irregularity in fermentation, difficulties in clarification, and, sometimes, incurable want of stability.

EMPIRICAL AND MOLECULAR COMPOSITION OF MALT.

The empirical composition of malt is not a subject much referred to by authors, whose attention has been mainly directed to the molecular constitution, and the determination of the relative proportions of the several carbohydrates, proteins, &c., present.

In 1846, a report to the Government on the use of malt for feeding cattle was prepared by Drs. T. and R. D. Thomson, in which the following empirical analysis of malt is given:—

Carbon	42·44
Hydrogen	6·64
Nitrogen	1·11
Oxygen	43·08
Ash	1·68
Water	5·05

A very large number of what may be called molecular analyses of malt have been published, principally in technical journals and books. A selection of the most typical of these is appended.

	Stein.[*]	Lermer.[†]	Sir J. B. Lawes.[‡]		Wigner and Harland.[§]	
Starch	50·876	55·016	72·03	67·97	69·13	60·83
Dextrine	8·232	7·724			5·75	5·70
Cellulose	18·817	8·231	4·84	5·75	6·36	8·20
Sugar	—	2·285	11·01	11·89	6·13	5·98
Fat	3·379	2·815	—	—	2·39	2·79
Extractive matter ..	4·650	3·558	—	—	—	—
Ash	2·290	2·364	2·17	2·48	2·44	5·73
Protein, soluble ..	1·985	18·005	9·95	11·91	4·27	6·21
,, insoluble ..	9·771				3·52	3·96

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[*] *Chem. Centr.* 1860, pp. 494, 575—578.

[†] *Polyt. Journ.* bd. clxxix. pp. 71—80 [1866].

[‡] Report on Malt and Barley as Food for Stock [1866].

[§] *Journ. Soc. Arts*, vol. xxxiii. p. 337 [1884].

The foregoing figures are those of the dry matter in the malt calculated afresh where not so published originally. As every sample of malt varies in the amount of moisture it contains, whether original or acquired by slackness, it is clearly necessary to consider the dry matter alone, in comparing malts, although the proportion of moisture is also a matter of grave import.

In dealing with the chemical composition of malt, I shall describe the nature, &c., of the several substances present, in the same order as when discussing the constituents of barley, viz.:—

I. Carbohydrates or non-nitrogenous matters.
  Starch.
  Cellulose.
  Dextrine.
  Sugars.
  Fats.
  Resins.
  Mineral constituents.

II. Proteins or nitrogenous substances.
  Amides.
  Peptones.

I.—CARBOHYDRATES.

1. Starch.

It is not necessary to repeat here the account of the chemical composition, &c., of starch already given on pp. 101—105. As it occurs in malt it is, or should be, wholly, or at least largely, in the soluble or amidin form, modified from its original insoluble condition by the process of germination. As has been pointed out before, it is, at least in respect of bulk and weight, the most important constituent of the grain and the success* of the maltster largely depends upon the modifications effected in the starch-granules by his operations. His aim is to render the starch susceptible of conversion into dextrine and maltose, without himself inducing such conversion, and with the production of as little lactic or butyric acid as possible.

There are, however, probably but few samples of malt which do not contain at least traces of both maltose and lactic or other acid. Different authors, by adopting varied methods of investigation, have arrived at widely discrepant results. Stein, for instance, denies the presence of any sugar soever in well-made malt; whilst Kühnemann finds sucrose (*i.e.*, maltose), and others record the presence of glucose—sometimes in large proportions. The sweetness to the palate of malt is perceptible on the instant of mastication; but this is due to the presence of the saliva either acting as water would do on the soluble proteins, and commencing diastatic action thereby, or itself converting the starch by the ptyalin it always contains.[*]

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* That is, in the production of good malt. Some commercial "success" does not imply this at all.

The chemical tests for sugar are much more reliable.

If malt be rapidly ground, and, as quickly as possible after the access of water to the meal, an infusion be tested for sugar, so rapid is the diastatic action, that much less sugar will be found than after a few minutes' delay, if any be found at all.

The readiness with which conversion takes place is probably due not wholly to the condition of the protein-constituents of the malt, but in some measure to the peculiarly unstable condition in which the starch-granules are left by germination.

The lapse of time and the conditions of storage are important factors in this matter. The residual moisture present in the most thoroughly-cured malt tends slowly to convert the starch to sugar and lactic acid, and the process is hastened by the absorption of damp, each molecule converted increasing the hygroscopic tendency of the mass.

There is another question for scientific research, viz., whether all or some only of the starch-granules are thus modified where germination has affected the entire kernel. The modification commences in the germ, and spreads over the surface of the endosperm, to the centre of which it gradually penetrates. But whether the extent of modification of the starch be affected by the size of the granules, by their relative proportions of granulose and cellulose, by the disposition within the granules of these substances, or by the relative proximity of gluten-cells, are points requiring further elucidation. It is even doubtful if the modified starch is converted to sugar by water in the absence of unstable nitrogenous bodies, as hitherto no means have been found of separating these diastatic substances from the unconverted granules, which they surround as cell-walls, and possibly intersect as concentric films.

In the process of germination a portion of the starch is converted into dextrine, a trace, occasionally, into cellulose, and about eight per cent. into sugar, which passes into the rootlets or is oxidised to carbonic acid gas and water. Altogether, from a fourth to a fifth of the starch ceases to be such.

Saussure,[†] in a series of elaborate experiments on the effect of germinating and of fermenting grain on the atmosphere of a closed vessel, found that more oxygen was consumed than was exhaled as carbonic acid gas, and that in the earlier stages of germination a considerable amount of nitrogen was also absorbed. It is difficult to conceive of the combination of gaseous nitrogen with any of the constituents of the grain, and T. C. Day[‡] found, in a similar series of experiments, that the nitrogen sometimes increased and sometimes decreased to a very small extent, proving that it takes no active part in the germination of barley. He also finds no constant ratio between the oxygen retained and that exhaled as carbonic acid gas, the proportion ranging from an eighth to a tenth. The oxidation of the sugar from the rootlets sets free a molecule of water for each molecule of carbonic acid exhaled, thus—

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[*] The ptyalin of the saliva appears to be akin in many respects to the proteins. It has high diastatic power, probably varying with the individual, and at different times in the same person.

[†] *Mém. Soc. Phys. Hist. Nat. Genève*, t. vi. pp. 445—581. 4to. [1834.]

[‡] *Journ. Chem. Soc.* vol. xxxvii. pp. 645—658 [1880].

$$C_6 H_{12} O_6 \times 12 O = 6 CO_2 \times 6 H_2 O.$$

The water thus set free is lost in drying.

Mr. Day gives proof that the substance oxidised is a glucose or grape-sugar, in the relation of the carbonic acid gas evolved to the amount of water set free.

2. CELLULOSE.

Cellulose has already been described (p. 105), and, apart from differences in its amount to be referred to presently, malting seems not to affect it. Its insolubility, at least for the most part under normal conditions, has led, perhaps, to its being less studied than the other constituents of malt. Remaining chiefly, if not wholly, as "grains" in the mash-tun, its convertibility, under special conditions, into saccharine matter has been little considered, at least in connection with malt.

It is difficult to ascertain what change, if any, takes place in the cellulose of grain during germination. That the steep-liquor penetrates the cell walls by osmosis, and commences to modify the granulose within, is a fact easily verifiable; but whether the cellulose of the walls or of the interior of the cells is broken up and carried in a soluble form into the devoloping embryo, or exhaled as carbonic acid gas and aqueous vapour, or remains within the grain, is yet an open question.

Lermer represents the cellulose as *increasing* nearly three per cent. by malting, 7·10 in the barley becoming 7·31 in the resulting 88·81 of malt. Stein, on the other hand, shows a *loss* of cellulose of more than 15·8 per cent., from 19·864 to 16·710. If the original cellulose remained unchanged, and the cell-walls of the acrospire were formed from sugar derived from the granulose and again changed to cellulose, a slight increase in the amount of that constituent of malt would be intelligible. On the other hand, if the original cellulose were in part broken down, and conveyed into the radicles, a loss to a much larger extent would be perceptible.

3. DEXTRINE.

There is little to be added to what has already been stated as to dextrine. It is uncertain whether it is affected by germination, as its percentage in barley is practically the same as in malt, and the range of five and a-half to eight and a-half per cent. given above, as found in various malts, is probably due to original differences in the barley rather than to variations in the effect of germination upon the dextrine.

4. SUGARS.

There are two classes of sugar, of which grape-sugar and cane-sugar are the respective types, but the terms glucose and sucrose are preferable, as these compounds are widely distributed, not only in the vegetable but in the animal kingdom. Both are merely class-names, applicable to a number of varieties, differing in their optical, palatal, and other physical characteristics, but identical (for each class *per se*) in chemical composition. The glucoses are hydrates of glucosan, the sucroses of diglucosan, or the latter class may be regarded as glucoses condensed with loss of water. From another point of view, sugars may be considered as aldehydes of glucosan alcohol, of which mannite is a type. The constitution of these several substances is shown by the following formulæ :—

Mannite or Glucosan Alcohol. — Glucose or Glucosan Aldehyde.

$$C_6H_{14}O_6 - H_2 = C_6H_{12}O_6.$$

Glucose. — Starch or Glucosan.

$$C_6H_{12}O_6 - H_2O = C_6H_{10}O_5.$$

Mannite. — Sucrose.

$$2\,(C_6H_{14}O_6) - H_2 = C_{12}H_{22}O_{11},\ H_2O.$$

Sucrose. — Starch.

$$C_{12}H_{22}O_{11},\ H_2O - 2\,(H_2O) = 2\,(C_6H_{10}O_5).$$

Solutions of various sugars exert a rotatory action upon a ray of polarised light, the degree and direction of rotation being proportionate, with fluids of equal depth, to the nature and amount of the sugar present. In the formula, $R = a\frac{V}{lp}$, R is the rotatory power required for comparison; a, the observed angle of rotation; V, the volume of solution employed; l, the length of column traversed by the ray; and p, the weight substance in solution. The specific rotatory power of several sugars, &c., has been found to be as follows :—

	Degrees.
Soluble starch (amidin)	+ 211·0
Maltose	+ 172·0
Dextrine	+ 138·7
Sucrose	+ 73·8
Glucose	+ 57·4
Invert sugar	— 28·0
Gum	— 36·0
Lævulose	— 106·0
Sinistrine	

But the specific rotatory power varies from several causes. Fresh glucose rotates twice as much as a few hours after its formation, and fresh maltose three times. By heating to 176° Fahr. and cooling, the minimum of rotatory power is at once reached. If this minimum of glucose be taken as unity, that of fresh glucose will be 2, of maltose 3, and of dextrine 4. Alkalies diminish the rotatory power, which neutralisation restores. Heat affects the optical properties of different sugars in a very marked way. Thus, Dubrunfaut found that in the case of cane-sugar the rotatory power at 212° Fahr. is 0·9768 of that at 32° Fahr., whilst for inverted sugar each degree of Fahrenheit's scale reduces the angle of rotation 0·205°, so that at 187° Fahr. it becomes *nil*, and at higher temperatures is reversed, and the solution shows a dextral rotation.

1. *Sucrose Sugars*, $C_{12}H_{22}O_{11}$.

1. *Maltose.*—Of the two classes of sugars mentioned above, the sucrose is that which first demands our attention in connection with malt, for the effect of diastatic action on starch is to convert it into a mixture of dextrine and maltose, the latter being a sugar of the sucrose type. (The relative proportions of these substances produced at different temperatures have been dealt with already, p. 104.)

Maltose, when free from glucose sugars, crystallises like cane-sugar or sucrose, but is distinguished from it by its great reducive action with Fehling's solution (cupro-potassic tartrate), and its much higher rotatory power. The reducive action is found, by Soxhlet, to vary with the degree of dilution. Maltose combines with lime to form calcic maltate, the solution of which is lævo-rotatory, as are those of other maltates, though the hydrate becomes dextro-rotatory by keeping.

By the action of dilute acids maltose is gradually converted into glucose. The characters of maltose have not yet been sufficiently studied, comparatively with those of sucrose.

Maltoic acid, produced by the action on maltose of bromine water, does not reduce Fehling's solution, and is isomeric, if not identical, with the so-called dextrinic and gluconic acids similarly formed from dextrine and glucose.*

2. *Sucrose.*—Sucrose, saccharose, or cane-sugar, occurs native in the sugar-cane, in beetroot, and in other vegetable juices. It dissolves in less than one-third of its weight of hot water, and the solution has a dextro-rotatory action on polarised light. Cold water dissolves a smaller proportion, and by slow evaporation the large and beautiful crystals known as sugar-candy are produced. Agitation during crystallisation checks the development of large and regular crystals, and produces the sugar of commerce, either a loose mass of dry crystals, or a "loaf" of the same, cemented by the deposition of more sugar between the minute crystals. The average density of crystallised sucrose is 1·6; it fuses at 320° Fahr., and forms the well-known barley-sugar, which is subsequently fusible at 200°, and consists, according to Gélis, of a mixture of glucose and lævulosan, the latter, $C_6H_{10}O_5$, being unfermentable.

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* HERZFELD, *Centr. Agrik.-Chem.* 1883, pp. 127—129.

Though barley-sugar gradually passes from the vitreous to the crypto-crystalline state, it will not, if kept long in fusion, crystallise from solution subsequently; and its rotatory power on polarised light is diminished.

At 400° loss of water takes place, and there is formed caramel ($C_{12}H_{18}O_9$). This is soluble in water, and its solution is precipitated by alcohol. It forms insoluble compounds with baryta and lead. At 420° it is carbonised.

Prolonged boiling at 230° destroys the power of crystallisation by causing the assimilation of a molecule of water and consequent formation of a mixture of glucose sugars, known as "inverted sugar." This change is expedited by the presence of as little as five per cent. of strong organic or mineral acids, or of the chlorides of alkalies or alkaline earths. Longer boiling causes the assimilation of a second molecule of water, and glucose results, with traces of formic acid and of ulmin, a brown sparingly-soluble substance which discolours the syrup. The use of vacuum pans, enabling ebullition and evaporation to take place at 150° Fahr., prevents the production of this uncrystallisable discoloured sugar or treacle.

Sucrose is instantly charred by concentrated sulphuric acid, by chloride of tin, and, at 212° by dry chlorine.

Dilute sulphuric and hydrochloric acids "invert" sucrose as described above; dilute nitric acid (Sp. Gr. 1·25) oxidises it to saccharic acid, and more concentrated nitric, to oxalic acid.

Sucrose is slightly soluble in cold dilute alcohol, and more so upon the application of heat; it is insoluble in ether, and nearly so in cold absolute alcohol.

Lime forms three distinct compounds with sucrose, by the combination of one, two, and three molecules respectively of lime with one molecule of the sugar. The first is formed by dissolving lime in cold dilute syrup, and precipitating the compound by addition of alcohol; it is bitterish and very soluble. The bicalcic substance is produced by digestion of the syrup with excess of lime, and alcoholic precipitation of the filtrate. The tricalcic compound is precipitated on boiling a solution of sugar saturated with lime, but is redissolved on cooling, being, though nearly insoluble in either hot or cold water, readily soluble in cold syrup.

With regard to the precipitation of lime saccharates from warm solutions, Degener* showed that it much depends on the compound formed. For the tricalcic saccharates, saturation with lime is requisite. The chlorides of alkalies or alkaline earths, if present in small quantity, assist the precipitation, but if in excess they prevent it.

Baryta forms an insoluble monobasic compound with sucrose, its analogous glucose compound being soluble.

Sucrose compounds with other bases are sparingly soluble in water, but are readily taken up by alkaline liquids. In consequence of this, sugar prevents the precipitation of many metallic oxides, including those of copper and iron.

* *Centr. Agrik.-Chem.* 1883, p. 127.

But in the absence of alkali many of the oxides are reduced by boiling with sucrose, the mercuric salts become mercurous, and those of gold yield the metal in a state of fine sub-division.

The cupro-potassic tartrate (Fehling's solution) is not reduced by sucrose, even on long boiling, and very little cuprous hydrate is precipitated from the test-mixture of cupric sulphate and caustic potash, which remains permanently blue.

Boiling sucrose takes up two molecules of plumbic oxide if freshly precipitated, forming the compound $C_{12}H_{20}(PbO)_2O_{10}$, which is precipitated upon cooling, and loses H_2O if heated to 212°. Another combination with lead is obtained by precipitating an ammoniacal solution of triplumbic dioxyacetate with lime sugar (the monocalcic compound). This reaction takes place according to the formula:—

$$Pb_3O_2(C_2H_3O_2)_2 + CaO, C_{12}H_{22}O_{11} = Ca(C_2H_3O_2)_2 \\ + C_{12}H_{16}O_{11}Pb_3 + 3H_2O.$$

Mixed with three times its weight of caustic potash, and slightly moistened, sucrose breaks up into propionic, formic, and acetic acids in combination with the alkali.

Sucrose is reduced by cupric hydroxide, with production of carbonic anhydride, formic, glycollic, and other acids. Alkalinity favours the process of reduction. But as the reaction only occurs after several hours' boiling, possibly inversion takes place prior to reduction.*

Briant† states that the ash found in all but the most perfectly refined sugar tends to prevent crystallisation, retaining in solution about 3·75 times its weight, so that where it amounts to two per cent. the refiner has seven and a-half per cent. of crystallisable sugar kept in solution.

Saccharic acid is formed by precipitating the base from tricalcic saccharate with oxalic acid. By evaporation the anhydride saccharine is deposited. Potassic saccharate is $C_6H_{11}KO_6$, cupric is $C_{12}H_{22}CuO_{12}$. The zinc and calcium saccharates are uncrystallisable. Nitric acid (Sp. Gr. 1·375) oxidises saccharic to oxalic acid, and a new acid, $C_6H_{10}O_7$, the aqueous solution of which has slight lævo-rotatory power.‡

2. *Glucose Sugars*, $C_6H_{12}O_6$.

1. *Glucose.*—Glucose, dextrose, or grape-sugar occurs in nature in fruit, honey, eggs, &c., and is produced in the process of brewing by the alteration of dextrine. It is from half to three-fifths as sweet as sucrose, and less soluble in water. It is insoluble in absolute alcohol, but enters into solution if so little as five per cent. of water be added. A saturated aqueous solution contains nearly equal weights of sugar and water, and is not decomposed by dilute sulphuric acid. Dry glucose fuses at 295° Fahr., is converted to glucosan at 340°, and burns at 420°, forming caramel by loss of three molecules of water from two of glucose, thus:—

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* HABERMANN and HÖNIG, *Monatsh. Chem.* bd. iii. pp. 651—667 [1882].

† Laboratory Textbook. 1884.

‡ KILIANI, *Ber. deutsch. chem. Ges.* bd. xv. pp. 2953—2960 [1882].

$$2\,C_6H_{12}O_6, H_2O - 3\,H_2O = C_{12}H_{18}O_9.$$

A bitter substance, termed assamar, is formed by a continuation of the process, and at a higher temperature carbonisation ensues, and a pure charcoal is left. The aqueous solution of glucose rotates the rays of polarised light to the right hand through an angle of 56°. Ordinarily evaporation of solution of glucose produces a granular crypto-crystalline mass, but anhydrous crystallised glucose has been obtained by Soxhlet and Behr[*] from concentrated syrup, aided by the admixture of methyl-alcohol, which keeps impurities in solution.

If common salt be present, large and regular crystals are formed, containing two molecules of glucose, with one of salt and one of water, thus:—

$$\begin{matrix} NaCl\,(C_6H_{12}O_6) \\ H_2O\,(C_6H_{12}O_6). \end{matrix}$$

Two other compounds of glucose with water and salt are known, but are less easily produced.

Glucose dissolves in concentrated sulphuric acid without blackening, producing sulpho-saccharic acid. By dilute nitric acid it is oxidized into saccharic acid $C_6H_{10}O_8, H_2O$.

On the other hand, caustic alkali boiled with glucose solution turns it dark brown or black, and acids precipitate from the discoloured syrup, a black powder, called melasinic acid, and having the composition $C_{12}H_{12}O_6$.

With a solution of cupric sulphate, to which potassic hydrate is added, glucose solution dissolves the cupric hydrate, but on the application of heat a heavy green precipitate falls, changing rapidly to scarlet, and ultimately to dark red, whilst the supernatant solution becomes nearly colourless as the cuprous hydrate settles down. A similar reducing action takes place with ferric, argentic, or mercuric salts, silver and mercury being reduced to the metallic state, whilst the ferric salts become ferrous.

Habermann and Hönig[†] state that strong, and if free alkali be present, immediate reduction occurs when cupric hydroxide is introduced into hot glucose syrup; carbonic acid is evolved, and the resulting solution contains formic, glycollic, and, if soda be added, glyconic acid. In neutral solutions the reduction is slower.

2. *Lævulose.*—Lævulose, occurring in fruit, &c., with glucose, differs from it in its lævo-rotatory action on polarised light, and its less ready oxidation to alcohol under zymotic influences.

It reduces Fehling's solution (cupro-potassic tartrate) with the aid of heat, and combines with lime to form a sparingly soluble compound, crystallising in needles, and consisting of two molecules of lævulose with three of lime $(C_6H_{12}O_6)_2, (CaO)_3$, closely analogous to the tricalcic sucrose compound previously described.

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[*] *Polyt. Journ.* bd. ccxlv. pp. 121—125 [1882], and *Centr. Agrik.-Chem.* 1882, p. 698.

[‡] *Monatsh. Chem.* bd. iii. pp. 651—657 [1882].

By the nascent hydrogen evolved from water by sodium, lævulose is converted into mannite, $C_6H_{12}O_6$.

At 338° lævulose loses water and becomes lævulosan, which, by boiling in water, is reconverted into sugar; lævulosan, being isomeric with dextrine, cellulose, and starch, is $C_6H_{10}O_5$; with dilute nitric acid, saccharic acid is formed.

Habermann and Hönig (*loc. cit.*) find that the reduction of a solution of lævulose by cupric hydroxide takes place much more readily than that of glucose or sucrose, but the products are the same, varying only in relative proportions.

Inverted sugar is reduced by cupric hydroxide at 212° Fahr., with evolution of carbonic acid gas, and the production of formic, glycollic, and other acids. By the presence of alkalis, the reduction is hastened and its amount increased.*

Inverted sugar formed as described under Sucrose, is a mixture, in equal proportions, of glucose and lævulose, which may be separated by the following process: Five parts of inverted sugar are dissolved in fifty parts of water, and three parts slaked lime added. The syrup becomes pasty, and, being strained. through linen, yields a fluid compound of lime and glucose, and a pasty one of lime and lævulose, the tricalcic combination mentioned above. The lime can be precipitated from these by oxalic acid, leaving the sugars.

5. FATS.

The fatty matters in malt have not been so much studied as those of barley and other grain in the natural state. They are reduced in amount by germination proportionately to the rate of the process, slow growth only diminishing the amount of barley fats by twenty per cent., whilst rapid growth causes a reduction of 30·2 per cent. The average in malt may be taken at 1·40 per cent.

6. RESINS.

The resins in the husk of barley are partly dissolved in the steep-water, and the rest are modified in germination, and to a larger extent in kiln-drying. The changes effected are, probably, the removal, as carbonic acid gas and water, of some of the atoms of these complex bodies, but that process does not of necessity imply simplification of the constitution of the resulting compound, where the loss of some atoms is accompanied by condensation of two or more molecules of the remainder. Oxidation, also, though generally meaning abstraction of carbon or hydrogen, may, in some cases, be the addition of oxygen to a body already of complex structure. Hydration, in like manner, may mean only the condensation of water, as such, within a molecule, or it may be that the hydrogen and oxygen become bonded respectively with separate atoms, not again to form water till the molecule is decomposed into its simplest constituents.

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* HABERMANN and HÖNIG, *loc. cit.*

Most of the natural resins are mixtures, sometimes of several substances, closely allied if not identical in composition, and differing chiefly in degrees of solubility in alcohol, ether, and other media. The flavour of malt-liquors, including whisky, depends greatly on the almost infinitesimal amount of resinous matter derived from the malt, and the subject is one that would probably repay careful investigation.

7. Ash.

The amount and composition of the mineral matter, or ash, of malt necessarily varies in every sample. Not only is the relative quantity of ash dependent on the extent to which organic ingredients and moisture have been removed from the grain by germination and drying, but the actual amount in the malt from a given weight of barley, fluctuates with the two independent factors, the original proportion and composition of the ash, and the extractive power of the water used for steeping.

There is not a great number of published analyses of malt-ash, most authors confining their attention to consideration of the organic matter present, and merely recording the total amount of ash.

In their report to the Government on the effect of malt and barley as food for cattle (1846), Drs. T. and R. D. Thomson give the following analysis of malt-ash:—

Silica	28·74
Phosphoric acid	38·34
Chlorine	trace
Peroxide of iron	1·59
Lime	3·89
Magnesia	9·82
Potash	11·72
Soda	5·90
	100·00

Lermer* gives the following:—

Silica	0·69861
Phosphoric acid...	0·73575
Sulphuric acid	trace
Chlorine	0·00405
Alumina	0·00917
Lime	0·08029
Magnesia	0·14231
Potash	0·37433
Soda	0·01731
Total in 100 of barley	2·06182

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* *Polyt. Journ.* bd. clxxix. pp. 71—80 [1866].

In 1883 Michel and Jäckel-Handwerck published, in an account of investigations into the chemistry of malting,* the following analyses of the ash of eight varieties of malt, viz.— 1, Hungarian; 2, Slavonian; 3, Ratisbon; 4. Bohemian; 5, Franconian; 6, Saal; 7, Moravian; 8, Swedish:—

	1.	2.	3.	4.	5.	6.	7.	8.
Silica	0·598	0·711	0·677	0·644	0·725	0·556	0·770	0·651
Phosphoric acid ..	0·929	0·868	0·904	0·708	0·779	0·784	0·880	0·093
Sulphuric acid ..	0·029	0.054	0·012	0·029	0·012	0·019	0·031	0·058
Lime	0·091	0·072	0·087	0·077	0·084	0·096	0·085	0·082
Magnesia	0·253	0.266	0·236	0·219	0·239	0·239	0·219	0·212
Ferric oxide ..	0·022	0·018	0·019	0·014	0·017	0·011	0·015	0·015
Potash	0·468	0·363	0·470	0·367	0·385	0·417	—	0·407
Total ash	2·480	2·390	2·440	2·300	2·420	2·350	2·320	2·310
Nitrogen	1·625	1·600	1·857	1·798	1·729	1·568	1·733	1·413

The composition of the ash of the original grain of these malts has been already given, p. 109.

II.—PROTEINS.

I have already described the composition of several varieties of nitrogenous matter as occurring, or alleged to occur, in barley. The effect of malting is to convert a portion of these glutens, by a process of hydration, into amides and peptones.

According to Professor Ullik,† normal malt contains no peptones, the soluble nitrogen-compounds being nearly all amides, though traces of peptones might be formed under certain conditions of manufacture or storage. Even in the process of brewing but little peptone is produced, and the important effects upon fermentation attributed to peptonisation are, in fact, due to the amount of amides produced by modification of glutens, so that the aim of the maltster should be the development of amides rather than of peptone.

On the other hand, Behrend and Stürcke give, in the Wochenschrift fur Bierbrauerei, 1884, an account of various experiments in malting, carried out at the Agricultural Academy of Höhenheim, in which nearly half the soluble nitrogen compounds are placed under the head of "Soluble Albumen," and the remainder under "Non-Albumen."

Converting the nitrogen-percentages given into those of the protein-compounds, we have the following:—

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* *Polyt. Journ.* bd. ccxlvii. pp. 82–85, 168—173, 214—218 (1883). Abstract in *Journ. Chem. Soc.* vol. xliv. pp. 631—633.

† *Allgemeine Brauer- und Hopfen-Zeitung*, 1882.

Proportions of Nitrogenous Bodies at Various Stages of Germination, calculated as Percentages of the Total Dry Matter present.

I.—Saal Barley.

Stage of Growth.	Soluble.	Non-Albumen.	Albumen.		Total.
			Soluble.	Insoluble.	
Original grain .	2·0739	1·1114	0·9625	9·3929	11·4668
Steep-ripe	1·3239	1·0427	0·2812	9·9729	11·2968
After 22 hours ..	1·3428	0·9928	0·3500	9.9729	11·3157
,, 62 ,, ..	2·3794	1·8607	0·5187	9·0249	11·4043
,, 86 ,, ..	2·8166	2·1666	0·6600	9·2267	12·0433
,, 134 ,, ..	6·5283	3·0533	3·4750	6·1746	12·7029

II.—Hungarian Barley.

Stage of Growth.	Soluble.	Non-Albumen.	Albumen.		Total.
			Soluble.	Insoluble.	
Original Grain	2·9971	1·8732	1·1239	12·4116	15·4087
Steep-ripe	2·2478	1·4985	0·7493	12·4116	14·6594
After 41 hours ..	3·8713	2·4976	1·3737	12·2245	16·0958
,, 89 ,, ..	7·1805	4·9327	2·2478	9·8505	17·0310
,, 113 ,, ..	7·6801	5·4323	2·2478	9·4992	17·1793
,, 137 ,, ..	7·6801	5·7445	1·9356	9·6239	17·3040
,, 185 ,, ..	9·3035	6·7435	2·5600	9·7881	19·0916
,, 209 ,, ..	9·2410	6·9308	2·3102	9·7881	19·0291

The Saal barley used was large-grained, 1,000 kernels weighing 732 grains. It was steeped in hard water for thirty-six hours, with a change of water at the twenty-fourth hour. It chitted at twenty-two hours, and at sixty-two the radicles were as long as the corn, the acrospire two-thirds up. At eighty-six hours the radicles were half as long again as the corn, and the acrospire three-fourths up. At 136 hours the overgrown malt had leaflets as long as the corn, and radicles of twice that length.

The Hungarian barley was smaller, 1,000 kernels weighing 680 grains. At eighty-nine hours the radicles were as long as the corn, the acrospire half to two-thirds up. At 113 hours radicles from one and a-half to twice the length of the grain; acrospire three-fourths up. At 137 hours the acrospire reached the top of the corn. At 185 hours a leaflet was out; and at 209 hours several large leaflets from each kernel, the radicles still not exceeding twice the length of the grain.

The increase in total percentage of nitrogenous bodies is partly due to the hydration of gluten to amides or peptones, but chiefly to the loss, by respiration, of carbohydrates.

The loss of nitrogenous matter by steeping varies from three to five per cent, but no further loss appears to take place on the growing floor.[*]

The foregoing tables include the nitrogen compounds of the radicles and acrospires, which contain a very large amount of these bodies, principally, if not wholly, in the amide form, and are lost to the brewer by the screening of the malt.

DIASTASE.

This name, which was originated by MM. Payen and Persoz in 1833,[†] is familiar to every brewer who uses malt, but it is questionable if it represents a real substance, or only an energetic condition of bodies known when inert under other names. The reality of diastatic action is one thing, the substantial existence of a definable compound entitled to that distinctive name is another.

Much controversy has taken place as to the nature of this hypothetical agent, the older writers treating of it as an individuality, whilst the more generally received view at the present time is to attribute hydrolytic power to several of the soluble proteins, retaining the name diastase for the variable mixture of these bodies yielded by malt, ungerminated grain, &c.

It would seem, too, that the diastatic energy of the different ingredients reaches its maximum at different temperatures, a heat, which destroys the power of some, merely fomenting that of others.

It is probable that diastatic power is possessed by a very wide range of unstable organic bodies, of which, as far as we at present know, nitrogen constitutes an essential part.

The terms enzymes, soluble ferments, &c., have been put forth as class-names, whilst invertin, nuclein, &c., are supposed to be individual forms, or species, occurring in vegetable organisms, and ptyalin, pepsin, pancreatin, &c., in animal secretions.

As a class they are coagulable at or below 212° Fahr., and are precipitated from solution by alcohol. By the action of certain reagents, such as borax, salicylic acid, &c., the diastatic energy is lessened or destroyed, without, apparently, any change in the constitution of the solution, though doubtless some internal alteration and rearrangement of molecular structure is effected.

Repeated precipitation by alcohol and re-solution produce the same effect. These facts, and those of the action of varying temperatures, fully account for the wide discrepancy in the statements of different authors as to the proportionate quantity of starch which a given amount of "diastase" can convert; a question which is further complicated by the subsequent alteration of the maltose and dextrine first produced, which may be promoted by the diastase at the expense of loss of energy.

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[*] Hosaeus (*Ann. Landw. Preuss.* bd. l. pp. 135—143 [1867]) asserts the evolution of ammonia during the steeping of barley.

[†] *Ann. Chim. Phys.* sér. 2, t. liii. pp. 73—92; t. lvi. pp. 337—371.

In 1879 Brown and Heron published a paper* on "The Transformations of Starch," of which it is scarcely possible to speak too highly as an addition to the classical literature of organic chemistry.

Towards the close of their work they detail the effects of heat on the cold extract of malt used as a standard diastatic agent, as follows:—

> "When malt extract is gradually heated, coagulation is first apparent at about 46° C. [115° Fahr.†].
>
> "When this temperature is maintained, the maximum amount of precipitation possible under these conditions takes place in from 15 to 20 minutes, a continuance of the heating having no further influence. If, however, the temperature is raised a few degrees, a further coagulation takes place, which in turn soon attains a maximum. This increase of coagulation with the temperature continues up to about 95° C. [203° Fahr.].
>
> "The amount of coagulation produced by heating equal quantities of normal malt extract to a given temperature is shown in the following table. The third column gives the quantity of precipitated albumen, calculated as a percentage upon the total amount thrown down at 100° C. [212° Fahr.].

100 *c.c. of Normal Malt Extract.*

Temperature.		Grains of Albumen coagulated.	Percentage of total amount.
Centigrade.	Fahrenheit.		
50°	[122°]	0·044	19·1
60	[140]	0·123	53·5
66	[151]	0·155	67·4
76	[169]	0·186	80·8
100	[212]	0·230	100·0

> Every stage in the coagulation of malt extract by heat is attended with a distinct modification of its starch-transforming power; and, conversely, we have never been able to discover any modification in starch-transforming power which is not attended with distinct coagulation.
>
> "In addition to this, at 80° to 81° [177° Fahr.], the point at which the diastatic power of malt extract is destroyed, nearly the whole of the coagulable albuminoids have been precipitated. We are consequently led to conclude that the diastatic power is a function of the coagulable albuminoids themselves, and is not due, as has been generally supposed, to the presence of a distinctive transforming agent.

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[*] *Journ. Chem. Soc.* vol. xxxv. pp. 596—654.

[†] Square brackets enclose additions to the original of this quotation.

> * * * * *
>
> "Diastatic action appears to be as inseparably connected with the coagulable albuminoids as the production of alcohol is with the yeast cell; and the evidence in favour of a causal connection of these phenomena appears to be as strong in the one case as in the other.
>
> * * * * *
>
> "During the process of germination the coagulable albuminoids must evidently undergo some change, which, without materially altering their physical properties, confers upon them a large amount of potential energy.
>
> "It is possible that these bodies consist of portions of the cell protoplasm (still retaining some of the properties of living protoplasm), which are thrown into a state of varying molecular tension whilst undergoing the modifications necessary for the requirements of the growing embryo. The direction of these modifications is probably from the extreme colloidal form to a state admitting of freer passage through the cell walls.
>
> "The molecular tension of the albuminoids results in great instability of composition, which is capable, under favourable conditions, of inducing the hydrolysis of starch.
>
> "We have, up to the present time, been unable to discover any marked change of state in the transforming agent attendant upon the liberation of so large an amount of energy. It is evident that some such change must take place, but it has hitherto escaped our notice."

Zulkowsky[*] describes a mode of extracting diastase from malt, consisting in its extraction by strong alcohol (in the cold); the filtrate being evaporated to dryness, made into a paste with glycerol, and placed in a vacuum for eight to twelve days. The mass is then squeezed, and the glycerol extract, diluted with water, is filtered into a mixture of alcohol and ether. The diastase is thus precipitated in flakes, drying to a white earthy powder, slightly soluble in water, forming an opalescent, slightly colloidal fluid, precipitated by acetic acid, sodic chloride, or sulphide, on the application of heat. The average of several analyses gave the following as the composition of this subject :—Carbon, 47·57 ; hydrogen, 6·49 ; nitrogen, 5·14 ; oxygen and sulphur, 37·64 ; ash, consisting of phosphates of potash, lime, and magnesia, with traces of sulphates, 3·16.

It is evident that this mode of preparation does not extract the normal diastatic elements of the malt, which are insoluble in alcohol; and the analyses confirm this, at the same time showing the wide range of composition of bodies agreeing in the possession of diastatic energy. May it not be said that this process is rather one of synthesis than of separation—that the diastase obtained is produced from non-diastatic substances by the agents used, and not pre-existent in the malt?

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[*] *Sitz. k. Ak. Wiss. Wien*, bd. lxxvii. th. ii. pp. 647—654 [1878].

AMIDES.

The tables given on p. 147 show the gradual increase during growth of the amount of amides, but the effect of drying is not yet accurately discovered. Gluten heated (after thorough washing) to 240° Fahr. in a closed tube is converted into peptones and amides, in which no trace of albumen remains. It is therefore probable that the heat of the kiln tends to promote the alteration of the albumen remaining in green malt; and it is found under some circumstances that more than two-thirds of the nitrogenous matter in malt consists of amides.

Prof. Ullik (*loc. cit.*) gives the following results of experimental mashings :—

In 100 parts of Malt.	A	B	C	D	E	F
Albuminoid nitrogen ..	0·124	0·0952	0·0004	0·249	0·2366	0·137
Peptone nitrogen.. ..	0·000	0·0586	0·0621	0·000	0·0314	0·018
Amide nitrogen	0·330	0·2000	0·3260	0·247	0·2370	0·265
Unknown nitrogen ..	0·005	0·0609	0·0109	0·017	—	—
Total	0·459	0·4147	0·3994	0·513	0·5050	0·420

A was a cold mash at 55°—60° Fahr.

B, of the same grist, was gradually heated to 167° Fahr, and kept so for an hour.

C, also of the same malt, after gradual heating to 167° Fahr., was boiled for half an hour.

D Good malt but old; same treatment as A.

E The same, with treatment of B.

F The same, gradually heated to 167° Fahr., then boiled for an hour.

The fluctuation of the proportions of amides and peptones is noticeable. The extraction-process necessarily leaves most of the albumen in the grains in an insoluble state.

PEPTONE (HEMIALBUMINOSE).

The question (implied in the above synonym) whether peptones should or should not be termed proteins or albuminoids is not one of much practical importance so long as the distinction between them and glutens is duly understood.

Peptones are soluble in cold water, and the solution is unaffected by boiling; glycerine has also a solvent action, but alcohol, ether, and chloroform throw down in neutral solutions a white precipitate which turns yellowish when dry and becomes brittle. Dilute chloride of iron gives a permanent precipitate, whilst that from a strong solution is instantly re-dissolved.

Peptones are precipitated by basic plumbic acetate, mercuro-potassic iodide, sodic sulphate, acetified ferrocyanide of potassium, or a combination of ferric acetate, and sodic phosphate, the three last only with boiling, and it is doubtful whether the ferrocyanide precipitate is formed, if no unmodified albumen be present.

Plumbic hydrate, with a trace of acetate, has no effect on a solution of peptone.

Tannin gives a brown precipitate in neutral or slightly acid, but not in alkaline solutions.

The precipitate given by mercuric nitrate (Millom's reagent) is brown, but turns red upon the application of heat.

Peptones are easily precipitated by phosphotungstic acid containing a trace of sulphuric acid.

The minutest trace of peptone can be detected by the characteristic red-violet colouration produced by sulphate of copper in an alkaline solution. This reaction, which is generally known as the biuret test, was first noticed by Hofmeister, and by the use of standard solutions serves even for quantitative determinations of peptone.

In the conversion of albumen into peptone Pöhl* finds no change in the specific gravity, rotatory power, or index of refraction, hence he regards the peptones as merely more soluble modifications of albumen. He gives the specific rotation $[\alpha]_D = -14{\cdot}779$ deg. when q (percentage of water in solution) $= 0$ and $[\alpha]_D = -63{\cdot}779$ deg. when $q = 100$ (an infinitely dilute solution).

The specific refraction $\frac{n-1}{d} = 0{\cdot}4212$ when $q = 0$, and $0{\cdot}3316$ when $q = 100$.

By the slow action of alcohol or of neutral alkaline salts, peptones are dehydrated back into albumens. The first stage is that of Meissner's β-peptone, precipitable by a mixture of acetic acid with potassium ferrocyanide. The second stage is Meissner's α-peptone, precipitable by nitric acid. Meissner's metapeptone, insoluble in cold water, forms the third stage; and in the fourth, neutral salts give a precipitate soluble in hot water, but separating again on cooling, indicating the presence of Meissner's parapeptone, Schmidt-Mulheim's propeptone, Kuhne's hemialbuminose.

PARAPEPTONES.

This name was given by Meissner to a class of nitrogenous bodies intermediate between the albumens and the peptones, and representing probably the first stage in the modifications, effected by malting, of the crude glutens of barley (see above).

Parapeptones are soluble in absolute alcohol, and are precipitated by excess of ether; the white flakes turn yellow by exposure to air, and deliquesce to a brown syrup, a hydrate being formed, the solution of which is yellow.

With mercuric nitrate a red precipitate is produced; with sodic sulphate, the solution clouds, but there is no precipitate, even upon the addition of acetic acid, but ether precipitates the solution.

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* *Ber. deutsch. chem. Ges.* bd. xvi. pp. 1152—1170 [1883].

No action is produced by nitric or hydrochloric acid, chlorides of iron or mercury, or acetified ferrocyanide of potassium.

Griessmayer holds that parapeptones are developed in malt during kiln-drying; Briant prefers to consider their production in boiling wort as the safer hypothesis.

Acidity in Malt.

In my account of the chemical composition of malt no mention has been made of the proportion, often considerable, of lactic and other allied acids, from which few samples of malt are free.

The omission has been intentional, as such acids indicate defect either in the original grain, the process of malting, or the storage of the finished product.

The determination of the amount of acidity in malt is a brewer's question rather than a maltster's, but if maltsters would master the principles of the few simple tests needed to determine acidity, and would frequently test their malt during growth and storage, much useful light would be thrown upon their work. Some practices would be discontinued and others initiated, whilst the defects of many buildings would no longer be tolerated.

Stored malt often increases in acidity with age, especially if it become slack.

The lactic, butyric, and other acids formed in malt, are due to the alteration of the starch and dextrine under the influence of the unstable proteins. The action is so far akin to that which produces the sugars, &c., in the mash tun, that it may rightly be termed diastatic; but whereas the organized ferments which promote the formation of sugar are saccharomyces, the disease ferments accompanying the development of lactic and other acids are schizomycetes. For the characteristic forms of these microscopic fungi, the works of Pasteur must be consulted. It is only necessary here to remark that the spores of these low organisms are everywhere present, adherent to all vessels and tools, and to the exterior of all grain, however thoroughly cleansed.

The conditions of germination of grain are practically those of development of these fungoid spores, but by judicious treatment it is possible to check the inferior, without injuring the superior, vegetation, or at any rate to prevent the numerical increase of the former implied in perceptible mould-development on floor.

Brynych* states that the special forms of bacteria, by which lactic fermentation is fomented, if not originated, make their appearance in the steeping-cistern, and are found in every vessel through which malt or its extract passes, even to the fermenting-tuns.

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* *Zeitschr. Brauind.-Ver. Böhm.*, 1880.

The broken or idle corns on the growing-floor, and the fragments of malt in worts, constitute a very favourable soil for this and allied species of ferments.

The temperature most suitable to their development is from 85° to 125° Fahr., and their vigorous growth within that range is one of several reasons for the maintenance of low temperatures in cistern, upon growing-floors, and, at a later stage, in fermenting-tuns.

Lehmann[*] holds that fatty matter is essential to lactic fermentation, and gives an instance of beer brewed from oats at Horn, in Styria, remarkable for its peculiar lactic-acid flavour. As oats have an average of 5·4 per cent. of fatty matter, against barley 2·1, and wheat but 1·8 per cent., this unusual production of lactic acid is supposed to be due, in part at least, to the excess of fats present.

Fat is not, however, necessary to the formation of lactic acid, which can be obtained from bodies entirely devoid of any fatty matter, although the fermentation method of production may be facilitated by the presence of fat.

Lactic acid is of the same empirical composition as dextrose, but its molecule is simpler, thus:—

Dextrose.	Lactic Acid.
$C_6H_{12}O_6$	$C_3H_6O_3$

By heating with care to 130° or 140° Fahr., lactic acid is rendered anhydrous, becoming $C_3H_4O_2$.

It can easily be converted to propionic acid, $C_3H_6O_2$ by the action of strong hydriodic acid. Considerable traces of propionates are sometimes produced in fermentation.

Butyric acid, $C_4H_8O_2$, is not uncommon in irregular fermentations, and caproic acid, $C_6H_{12}O_2$, sometimes accompanies it.

Acetic acid is well-known as vinegar, and traces of it may occasionally be found in malt, though its volatilization by the heat of the kiln lessens the amount detectable in the green malt. Its composition is $C_2H_4O_2$.

Succinic acid, $C_4H_6O_4$, is a body very rarely occurring in malt, and requiring only bare mention.

With these acids, traces of their corresponding alcohols are generally present, especially the vinic, butylic and caproic alcohols.

Fitz,[†] in a series of memoirs published by the German Chemical Society, has investigated the schizomycetic fermentations of various organic bodies.

He found that a trace of schizomycetic ferment introduced into a mixture of 100 parts starch, 0·1 potassic phosphate, 0·02 magnesic sulphate, 1·6 ammonium phosphate, 40 calcic carbonate, and 3,000 water, induced fermentation in twenty-four hours, yielding a little alcohol, mostly vinic, and much acid, of which eighty per cent. is butyric, and the rest acetic acid, with a little succinic acid. Dextrine gave more alcohol than did starch.

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[*] *Berzelius' Jahresbericht*, p. 682.

[†] *Ber. deutsch. chem. Ges.*, bd. ix., pp. 1348—1355 [1876]; bd. x., pp. 276—283 [1877]; bd. xi., pp. 42—55 [1878]; bd. xii., pp. 474—478 [1879]; bd. xiii., pp. 1309—1312 [1880].

The fermentation of starch by the ferment described as *Bacillus subtilis*, affords an excellent means of producing butyric acid, though yielding only vinic alcohol, whilst the *Butyl-bacillus* produces butyl alcohol.

The discovery of oxalate of lime as an incrustation in a cooler led Siewert* to investigate the materials used. The malt was found to contain 0·0015 per cent. of oxalic acid, and germinated grain 0·064 per cent.

The composition of oxalic acid is $H_2 C_2 O_4$, one of the simplest organic compounds. The insolubility of its calcic salt renders the mode of its discovery in malt rather singular; probably the water used for steeping and mashing was devoid of calcareous matter, and the oxalic acid met with no precipitating base till some soluble salt of lime was formed from the ash of the malt.

TESTING MALT.

For the practical uses of malt it is essential to know the actual proportions of each constituent present; and a sample of every bulk of malt should be subjected to careful processes of testing its quality.

This is to a certain extent the function of the brewer or distiller who purchases the malt, but a maltster who regulates his work by its results should be able to examine those results himself, without depending on his customers' reports. Where a maltster is also a brewer or distiller, the desirability of his power to test malt in sample is increased.

The first point to determine is the amount of moisture. 100 grains is a convenient weight for this purpose, and the loss, after drying on the water bath for several hours, at once gives the percentage of moisture.

For the extract determination, a miniature mash of 200 grains is made in 3⅓ oz. (Troy) of water at 150° to 160°. This is filtered, and the grains washed with 5 oz. of water at 160°. The grains are dried over the water bath, and the loss of weight (allowing for original moisture) gives the weight of extract. The wort obtained is a five per cent. solution, the water weighing twenty times the malt. To convert the weight of extract into pounds per quarter per barrel the specific gravity of the wort must be ascertained, and also the weight per quarter of the malt. Then—

$$\frac{(\text{SG}-1000)\times \text{W}}{6} = \text{lbs. per quarter per barrel.}$$

If the malt weighs 42 lbs. per quarter, and the specific gravity of the five per cent. solution is 1012·34, we have—

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* *Landw. Versuchs-Stat.*, bd. xxviii., pp. 263—270 [1882].

$$\frac{12{\cdot}34 \times 42}{6} = 86{\cdot}38 \text{ lbs. per quarter.}$$

The next point to determine is the relative proportion produced of saccharine to dextrine. This is done by the use of a standard solution of cupro-potassic tartrate (Fehling's solution). This is prepared by dissolving in an ounce (Troy) of water 28 grains of dry powdered sulphate of copper; and, in another ounce of water, 82½ grains of crystallized tartaric acid and 100 grains of caustic soda. These solutions are kept separate, and used in equal quantities.

The wort is diluted to ten times its bulk and run from a graduated vessel into a flask, containing as much of the Fehling's solution as the original quantity of the wort, till the delicate blue tint disappears after boiling a few moments.

The percentage of maltose on the original malt is found by dividing 13·77 by the percentage of dilute wort used.

Another portion of wort, diluted to eight times its original bulk, has one-fifth part of sulphuric acid added to it, and is boiled for some hours, evaporation being replaced by distilled water. It is then made up to ten times the original quantity, and tested with Fehling's solution as above, to determine the amount of glucose produced by the action of the acid on the maltose and dextrine. The factor, 84·00, is divided by the percentage of dilute wort used, the quotient giving percentage of glucose of original malt. As maltose increases in weight one-nineteenth and dextrine one-ninth, it is necessary to add one-nineteenth to the ascertained amount of maltose, and deduct the result from the glucose, the remainder being due to the dextrine, deducting one-tenth for hydration.

Let ·265 be the amount of dilute wort used in the maltose determination, then 13·7 ÷ 7·265 = 50·196 per cent. of maltose. Next, let ·123 be the dilute wort used in determining the glucose, giving 84 ÷ ·123 = 68·293 of glucose. Of this 68·293, 52·838 is maltose hydrated by the acid, and 15·455 is saccharised dextrine, the original percentage of which was, therefore, 13·910.

The percentage of soluble albumen is obtained by evaporating to dryness the extract from a known weight of malt, igniting the residue in a closed vessel with caustic soda or soda-lime, and receiving the ammonia evolved from the nitrogen compounds in bulbs containing a known amount of sulphuric acid. The residual acid is neutralised by a measured quantity of standard solution of soda; and the amount of ammonia produced is thus found. This, multiplied by 5·15, gives the quantity of soluble albumen that yielded it.

The determination of the acidity of malt is still more simple. The extract from a known weight of malt is neutralised by a standard solution of soda, dropped in from a graduated burette. The acid, calculated as lactic, weighs one-eighth more than the dry soda required to neutralise it. The precise moment of neutrality is determined by litmus paper, or, still better, by a few drops of phenol phthalen (an aniline compound) dissolved in alcohol. The pale brownish tint turns instantly to a fine crimson when the acidity is converted to alkalinity.

Probably the best practical test for malt is "the Forcing-Tray Test." This is an apparatus and test far too little used or understood by maltsters. It is fully described and illustrated in Mr. Faulkner's admirable book, "The Theory and Practice of Modern Brewing." The method of testing is thus lucidly explained (p. 114).* "Let us take one or two large test tubes, " of 200 c.c. capacity, boil in them about 100 c.c. of distilled " water, plugging up the ends lightly with cotton wool; on " ebullition resulting, the steam blows through [the] wool, " practically sterilising it, and the test tubes, with their fluid " contents, are then placed in a beaker of cold water, and in " a few minutes we introduce a teaspoonful of the crushed " malt we are experimenting upon into our tubes, the beaker " being then placed over gas, and the temperature of the " whole arrangement raised to 150° to 155°. We have, in " fact, in our test tubes, miniature mashes, and by occasionally " shaking up contents, we promote saccharification, and in the " course of a couple of hours the supernatant wort brightens. " The tubes containing the mashes are now cooled down and " placed in pockets of forcing-trays, the wort in each being " examined at the end of every twelve hours. A good malt will " give a solution remaining absolutely unaltered at the forcing " tray temperature (75°) for 24 hours, or at a temperature of " 60° for even 36 to 48 hours, while inferior malts comport " themselves quite differently."

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* FRANK FAULKNER, The Theory and Practice of Modern Brewing, p. 114. (F. W. Lyon, London, 1884.)

CHAPTER XII.

MALT (*continued*).

Malt:—

Brown or Porter Malt. Amber Malt. Diagram of Kiln-Heats. Crystal Malt. Imperial Malt. Black or Patent Malt. Wheat Malt. Gelatinised Malts: Rice, Maize, Wheat, Barley, and Rye. White Malt. Maize Malt. Short-malt Germless Maize. Germless Maize. Southby's Maize Meal. Dari Kôji. Analyses of Kôji. Chica. Bye-products of Malt. Combes. Analyses of Combes. Kiln-dust. Screenings. Steep-liquor. Analyses of Steep-liquors.

NUMEROUS other descriptions of malt are made and used than that to which chief attention has been directed hitherto. Of these the chief are:—

Brown, blown, snap, or porter malt.
Amber malt.
Crystal malt.
Imperial malt.
Black, roasted, chocolate, or patent malt.
Wheat malt.
Rye malt.
Gelatinised malt; rice, rye, wheat, maize, and barley.
White malt.
Kôji.

BROWN, BLOWN, SNAP, OR PORTER MALT.

Slight differences only are made in the processes of manufacture of this article from ordinary or pale malt in all stages, excepting the final one of drying.

So long as the duty remained in force, the barleys selected for snap malt were small, and in other respects of an inferior quality. It was chiefly necessary that they should be kindly, and would germinate perfectly. Colour, and to a certain extent size, was immaterial, as the action of the fire when the corn was drying upon the kiln entirely hid both.

It is difficult to make up for practical experience by any written or verbal directions, no matter how plainly given. The subtle, and often indefinable, indications that lead a practised maltster to different procedure, or mode of work, cannot be conveyed to another in words. Probably few other processes are so difficult of explanation as drying and snapping off a kiln of blown malt. A description is easy enough, but from that alone it would be almost folly for anyone to attempt practical working. Experience is here the best teacher.

A number of porter malthouses are worked at Bishop's Stortford and other places, and a large amount of this malt is made annually. The use of the article is, however, deservedly dying out.

Usually in its preparation steeping, couching, and growing are conducted in the ordinary way. Some maltsters, however, give a little less time upon the withering-floor. The corn is then laden upon the kiln at a thickness rarely exceeding one and a-half inches. The fire consists exclusively of wood, generally of oak, but occasionally of beech. Billet and faggot wood are used. Great skill and care are needed properly to tend the fire and turn the floor. This is done only once, and the whole drying is completed in one and a-quarter to two hours. Moderate heat is maintained at first until the moisture has been largely dissipated, then the fire is made up, and flares and blazes so that no little danger exists of the corn igniting. This renders the work of the kiln-man both risky and laborious. The sudden and intense heat causes all the grain that has been properly grown to swell to the extent of twenty-five per cent., and the nature of the fuel employed communicates, very agreeably, the empyreumatic properties that distinguish this class of malt. Those corns that have not vegetated do not swell, and lack the requisite colour and flavour. Hence the care needed in the selection of the barley, as the vegetative capacity is the main consideration. Apart from the quality of the malt produced, the whole of the profit of its manufacture depends upon the swell, consequently the price is invariably below the average price of ordinary malt. The actual cost of manufacture of this malt is also greater than of pale, as fuel and labour in kiln approaches 3s. per quarter, and frequently exceeds it.

The quantity of fuel required is from eight to ten faggots per quarter dried.

Champion* states "that the making of this malt principally consists in half-drying, and sprinkling a little water over what is intended for snapping the next morning, which is done to toughen the skin of the grain. Beech-wood is preferred to dry or snap with. The corn to be spread on a kiln (wire it should be) about one inch and a-half thick, and turned about every four minutes, but at last oftener. Sweep clean with a broom after the persons who turn it."

AMBER MALT.

This malt is used by brewers chiefly to impart flavour and colour to many kinds of beer, especially to give to porter and stout the brown head that is so much admired.

Two kinds are made, the difference being in shade or colour; the better the quality of the barley used, the better the resulting

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* The Maltster's Guide, p. 195.

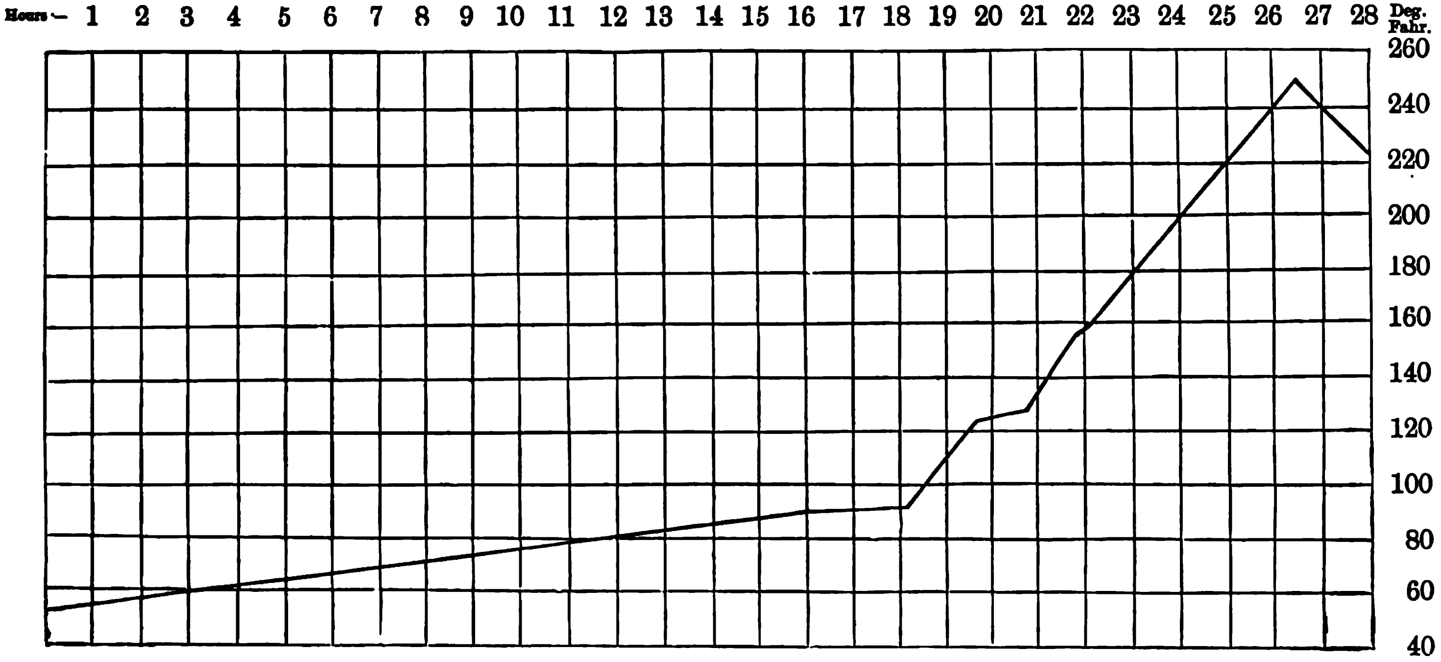

FIG. 6.—DIAGRAM OF HEATS DRYING AMBER MALT IN TWENTY-EIGHT HOURS.

malt. The working is the same as for pale malt in steeping and growing, and very similar in drying upon kiln.

Here the load or depth of corn upon floor should not exceed four inches, and much turning is not required.

The fire may be of a moderate warmth of coke or anthracite coal, until the moisture is dissipated. Then the heat can be very largely augmented, and if a good quantity of billet-wood is thrown upon the fire, the result is the better. The best flavour is given by beech-wood, which, however, must be quite dry. Fig. 6 gives clearly the time of drying and range of heats employed in finishing amber malt.

Very high-dried and amber malts, especially when mashed upon the decoction method, give a certain degree of viscosity to the beer produced. This characteristic of the Munich beer, for instance, has been attributed by Griessmayer and others to the drying of the malt. Thausing* conclusively proves it to be the existence of parapeptones in highly-dried malt which gives both colour and viscosity.

CRYSTAL MALT.

This was originally the subject of a patent which has long become void.

It is prepared in all ways like roasted malt, with the exception that, instead of being kiln-dried, and roasted in a sheet-iron cylinder, it is taken straight from the withering-floor at the seventh or eighth day, and placed in a roasting-cylinder made of wire. This is necessary in consequence of the very large amount of steam disengaged in the dissipation of so much moisture as is naturally present, and for which ready egress must be provided. Crystal malt is pleasantly sweet to the palate, but the sweetness is fictitious and readily accounted for by the mode of its drying. Sufficient moisture is present at high temperature to enable the soluble albuminoids to convert a portion of the starch into sugar, for as the malt when first heated is saturated with water, the amount of steam generated is considerable.

It is a very common opinion that malt contains much sugar because of its sweetness. This is simply a popular delusion, as malt rarely has more than one-half per cent. of sugar, and often none at all. If the tongue and palate be dried, and malt-flour be placed thereon, very little sweetness is detected; but the moment the saliva comes into contact with the flour, the peculiar and well-known sweetness of malt is perceived, as the diastase can then act upon the molecules of starch, and conversion to sugar instantly commences.† Crystal malt yields an actual extract very considerably below pale malt, amounting in many cases to upwards of 30 per cent. It is also deficient in colour, and, in the opinion of many brewers, supplies no want in any class of beer that cannot be much better filled by other sorts of malt less costly and dangerous in their use. Still the fact remains that a large quantity of this malt has been made and used, and a number of brewers continue to like its use.

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* The Theory and Practice of Preparation of Malt and the Fabrication of Beer. American edition (1880), p. 188.

† The physiological questions involved here are purposely overlooked.

IMPERIAL MALT.

Imperial malt differs from amber or brown malt very slightly, and the only difference between it and pale malt is occasioned by the method of drying and fuel used in the kiln-furnaces or cylinders. Ordinary pale malt is frequently made into imperial by carrying the finishing heat on kiln for several hours to 240°—270°, using for fuel, oak or (preferably) beech-wood.*

In a series of experiments made by Combrune† in the middle of the last century a very erroneous conclusion was formed of the heats requisite to give colour to malt when drying, although, curiously, a conclusion drawn by him from these experiments is worthy of very great attention. This was the relative times of keeping acquired by beers when brewed from malts dried at certain temperatures. The figures of temperature are entirely fallacious, but the truth taught by them remains, and the error as to degree of heat is easily rectified. So valuable is the right consideration of this subject that it is desirable to reproduce the table framed by Mr. Combrune‡ :—

Drying heat of Malt. Degrees.	Colour.	Duration of stability of Beer.
119	White	2 weeks
124	Cream colour	1 month
129	Light yellow	2 months
134	Amber	4 "
138	High amber	3 "
143	Pale brown	4 "
148	Brown	6 "
152	High brown	12 "
157	Inclining to black	18 "
162	High brown, speckled with black	2 years
167	Blackish brown, with black specks	—
171	Colour of burnt coffee	—
176	Black	—

Erroneous as we now know these temperatures to be, the deduction made is, on the whole, correct, and one which maltsters and brewers alike do well to remember.

BLACK, ROASTED, CHOCOLATE, OR "PATENT" MALT.

The introduction of black beers, or porter and stout, as they are usually called, led to the need of some colouring material that should permanently give the requisite colour and flavour. At first brown or amber malts were used, until it was discovered that malt roasted to a certain degree of blackness gave not only a sufficiency of flavour, but an enormous excess of colour, so much so that one bushel of black malt replaced successfully thirty bushels of brown. Its use became of course general in all porter- and stout-breweries, and a considerable trade in roasting grew apace. As it was found that very few users could tell the difference between roasted malt or barley, a wide field for fraud opened out, for, at that time, malt paid a very heavy duty. An Act was passed (5 and 6 Vict., cap. 30) which virtually made the roasting business a close monopoly. Ordinary maltsters were sufficiently tied, but roasters were placed under the closest surveillance, and fettered by regulations affecting the minutest details of their business, the infringement of any of the clauses being visited with the infliction of the heaviest penalties. As many classes of traders were shut out, and few could comply with the strict regulations as to the site of the premises, &c., not many entered into the business.

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* This does not describe the patent process of Messrs. Stanbridge and Co.

† The Theory and Practice of Brewing (London, 1762), p. 88.

‡ *Ibid.* pp. 94—97.

The old obnoxious system of barley- and stock-books was also retained for this particular branch of the business, when all others were liberated, and removals of roasted malt could only be effected at certain hours, and accompanied by certificates. The direct issue of all these causes was, they produced a close monopoly, and, to a certain extent, secured to a brewer roasted malt, and not roasted barley. The object of a roaster in using barley formerly was to secure the value of the duty paid upon malt. As this motive no longer exists, the only difference now between malt and barley to the roaster is the small cost of malting. As the difference in the value of roasted malt and barley when used more than covers this cost, brewers are much more likely now to get malt when they intend to buy it than was the case previously.

As, however, with the repeal of the Malt-tax, the Roasting Acts were also repealed, anyone is now at liberty to make roasted malt, and upon any premises. Several reasons point to the desirability of doing this. The process is a simple one, and the apparatus needed very inexpensive.

Black malt requires to be used immediately after roasting, to give its full flavour and aroma to beer. By making each day sufficient for the following day's use, this can be accomplished; for very few articles are so extremely hygroscopic as roasted malt, nor have many articles the value and full flavour so impaired by dampness. Very fine roasted malt can be prepared from ordinary pale malt. Roasters, however, used to malt specially, so as to keep just within the letter of the law. They would steep corn for forty hours only, as they might not steep it less, and by shortening the time they diminished the duty payable by fully five per cent. Scant time also was allowed upon the floors, as the usual allowance from cistern to kiln never exceeded seven days, and sometimes did not exceed four. Ford* states:—"Corn perfectly malted will not give out so much of "colour or so standing a colour as that merely partially

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* Malting and Brewing, p. 69.

" malted; and, on the other hand, barley *unmalted or not* " *steeped* gives still less colour, and the colour is not " permanent."

This latter statement is perfectly true. Unvegetated barley cannot by any known process be made to give so permanent a colour, nor so much of it, bulk for bulk or weight for weight, as malted grain. The flavour is also very inferior, and the aroma can bear no comparison. Well-made malt, on the other hand, is capable of being roasted satisfactorily, and of yielding more colour of a purer kind with inimitable aroma and flavour. The cause is palpable. More colour and flavour can be obtained from sugar subjected to a high temperature than from starch, and as malt has a large percentage of its starch so affected that it is converted into sugar very readily, and is capable of yielding to the influence of heat more easily than barley, it is only natural to find in practice that malt gives more colour and flavour of greater delicacy. Good coffee is rarely to be found in Great Britain, *i.e.*, the beverage, not the berry, for the finest coffee the world grows is sent to London. Throughout the East, Italy, and other places, exquisite coffee is invariably obtained; a great part of the secret rests in the fact that the coffee is roasted, ground, and made, all in the same day. Coffee, however, stands the influence of the air far better than malt, and any one desiring the full benefit of the aroma of roasted malt must prepare it on the spot, and grind it at once.

A sample of properly-roasted malt is uniform in colour, of a chocolate hue, not black, and each corn clear and clean. If it is black, with the corns burst, and especially if matted or run together, it is of a most inferior kind; and neither good flavour nor permanent colouring can be expected from it.

Every brewer in Germany has his own malt-roaster (Fig. 7). This is a simple fireplace enclosed with sheet-iron, fitted with a chimney to convey away steam, smoke, and fumes. In it is a small sheet-iron cylinder, freely perforated, holding one or two bushels of corn, and placed a short distance above the grate, on bearings that permit it to be freely turned. The corn is put in this cylinder over a low coke fire, and it is kept constantly turning slowly. As the steam passes off, the fire brightens, and the heat increases. In thirty minutes all the steam has passed away, and a fine rich aroma begins to steal from the malt. This increases quickly, and in five minutes it is necessary to inspect it. If the process has been rightly managed, a good chocolate tinge has been acquired, which quickly deepens, and in forty minutes the operation of roasting is complete. The malt is turned out to cool and mellow, and a second charge can be at once placed in the cylinder, and the operation repeated. A very short experience is sufficient to give a considerable degree of skill to any common workman, so that malt of a uniform colour is easily produced; and few manufacturing processes are more simple. The power to use this malt whilst quite fresh adds largely to its value. Pale malt also, if slack, is better roasted and used for colouring than when re-dried and mashed in the ordinary way, for it is an error to suppose that re-drying clung-malt restores to it its original quality and goodness; such malt can be more safely utilised by making it into "Patent," or by giving it a good amount of colour and flavour over a fire of beechwood. The influences and causes of the high colour which malt can acquire are not yet understood. By the process just described, we know that the malt has acquired a bitter taste, with the empyreumatic characteristics fully-developed, whilst a part of the organic matter has been carbonised. As a consequence, caramel and assamar are also present.

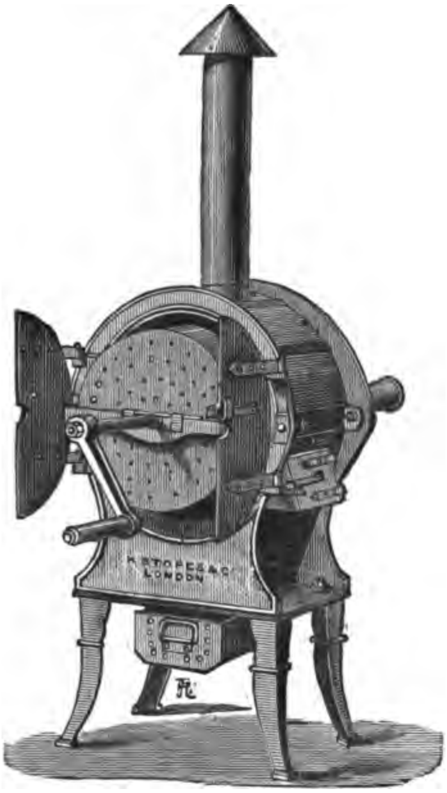

FIG. 7.—MALT ROASTER.*

WHEAT-MALT.

Wheat-malt would doubtless be much more largely made and used, especially at the present price of wheat (32s. per imperial quarter, Dec. 1884), were it not for the difficulty of growing it with the acrospire outside the husk. Further, its excess of gluten, and other nitrogenous constituents, give brewers much trouble in their existing state of knowledge.

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* See also Fig. 110, p. 293.

Consequently, wheat-malt is rarely made, and little known. It differs from barley-malt in itself, and is much more difficult to make. In 1834-5, wheat was cheaper than barley, and, accordingly, a considerable quantity was made into malt. Owing to the great difficulty of working up a floor without damage to the growing acrospire, many maltsters mixed wheat and barley together.

At that time[*] 13 bushels of barley were found to produce the same quantity of beer of standard gravity as 9 bushels of wheat, 10 of rye, or 19 of oats.

The ingenious writer of The London and Country Brewer[†] states that wheat-malt was cheaper at 3s. per bushel than barley at 2s.; at which time it was largely used in the manufacture of mum and very strong ales. Dugdale or Rivett's wheat was most commonly used. The author of Every Man his own Brewer,[‡] states that "Wheat was formerly the only "grain esteemed worth malting."

RYE-MALT.

In times of scarcity and dearness of barley and wheat, rye is made into malt. Stronger objections to its use exist than is the case with wheat, chiefly in consequence of the tendency to butyric fermentation generally found in beer brewed from rye. (See pp. 59, 60, 154.)

In 1858 experiments were made by the order of the Commissioners of the Excise Department, to determine the swell of rye in cistern and couch. It was then proved to increase to an extent equalling 30 per cent. of its original bulk, and, as a consequence, the duty paid was charged on the basis of such increase in working.

The manufacture of rye into malt is similar to that of barley, but it is not unusual for maltsters to mix it with equal quantities of heavy oats.

MAIZE-MALT.

In the early part of this century, Indian corn, or, as it was then called, "Virginian wheat," was made into malt by germination. The corn was simply sown very thickly in well-prepared fine soil or sand, and watered. After the blade had appeared well above the ground (generally in ten to fourteen days), so that the plot of ground was perfectly green, it was dug up, and carefully sifted, or well washed, to free it from earth. It was then dried in the ordinary way upon a kiln, and has been spoken of as having made very excellent malt. It was found essential to allow the blade (or acrospire) to shoot up at least eight inches, as otherwise the malt was the source of trouble to the brewer.

More recently maize has been gelatinised (see p. 168), and prepared in numerous ways for general use as a substitute for malt. It is not necessary to consider or describe all these methods; simply those that prepare maize in any way as malt will suffice. (See also Germless-Maize, Short-Malt, &c.)

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[*] Tizard on Brewing. Ed. iii. (London, 1850), p. 46.

[†] The London and County Brewer. Ed. ii. (London, 1743), p. 93.

[‡] Every Man His Own Brewer. (London, 1768), p. 10.

Other malts are now known to commerce. It is extremely difficult to procure information concerning the manufacture and nature of some of them, and that they are classed here with malt at all will doubtless be objected to by some.

Of these mention may be made of short-malt germless-maize, short-malt rice, germless-maize, Beane's patent grist, granulated grain, zealine, cerealine, grits, hominy, &c.

Short-Malt Germless Maize.

This is prepared by being thoroughly cleaned, degermed, and granulated by an elaborate and patent process, by means of which all the mechanical work is done with care, and the final drying is carried out at temperatures exceeding 240° upon Tomkins' patent or other kilns. (See Fig. 1.)

The following are analyses by Mr. T. W. Lovibond of short-malt, &c.:—

No. 1. Maize.
,, 2. Germless Maize.
,, 3. "Short-Malt" Germless Maize.
,, 4. Rice.
,, 5. "Short-Malt" Rice.

Analyses.

	No. 1. Maize.	No. 2. Germless Maize.	No. 3. Short Malt Germless Maize.	No. 4. Rice.	No. 5. Short Malt Rice.
Moisture	11·78	12·66	·84	11·50	1·14
Ash	1·46	·86	·98	·68	·74
Fat	4·12	2·32	2·50	·84	·88
Albuminoids—Insoluble	9·30	9·53	10·26	7·55	8·65
Do. Soluble	·50	·35	·25	·15	·05
Gum, Dextrine, &c.	7·88	4·70	4.84	1·72	2·00
Starch	54·49	61·06	70·23	74·97	83·24
*Cellulose, &c., unconvertible ..	10·47	8·52	10·10	2·59	3·30
	100·00	100·00	100·60	100·00	100·00
Extract in lbs. per quarter of 336 lbs.	88·58	93·14	106·04	108·18	120·02

Germless Maize.

Robertson's germless maize is prepared by removing from maize the germ in which are found the greater portions of the oils and other objectionable matters. The germ is removed by a process and special machinery duly patented. The following analyses by Dr. Clark sufficiently explain the result:—

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* An analysis by the acid-process would have reduced this, correspondingly increasing the starch.

	Danubian Corn. Per Cent.	Germless Danubian. Per Cent.	American Corn. Per Cent.	Germless American. Per Cent.
Starch	64·89	72·18	63·46	72·15
Nitrogenous compounnds ..	11·60	10·27	11·64	8·98
Gum and Sugar	4·53	2·59	4·75	2·10
Oil	4·30	1·05	3·62	2·02
Woody fibre	1·71	·61	3·75	2·05
Ash	1·27	·34	1·15	·68
Water	11·70	12·96	11·63	12·02
	100·00	100·00	100·00	100·00
Increase in value for distillers	—	8·24	—	9.53
Increase for starch makers	—	11·23	—	13·67

This germless maize is largely used by brewers in place of both malt and sugar.

Zealine is made and used chiefly in America. It is prepared from white maize, and its composition is indicated by the following analysis:—

Carbohydrates	77.76
Fats...	2.88
Acid...	0.06
Ash	0.36
Albuminoids	7.00
Water	11.94
	100.00

GELATINISED MALT.

Until very recently malt was made, commercially, by germination solely, and almost exclusively from barley. Since the repeal of the Malt Duties numerous other methods of manufacture have been attempted, in some cases successfully, and many other varieties of grain have been malted.

Consequently we now have a diversity of materials, a number of which can be fittingly classed with malt. Those most generally known commercially are:—

Gelatinised Rice.
„ Maize.
„ Wheat.
„ Barley.
„ Rye.
White malt.

All these are manufactured in such a manner that they are true malts in many respects. That they should be termed malt has been often questioned. No controversy need be raised upon the point, for any material which is called malt, and which is in itself, both by its process of manufacture and in its results, so closely allied to malt, decidedly comes within the scope of a work upon malt-making.

The gelatinisation of grain is the most important of the surrogatory processes. It was invented in 1880 by Messrs. Gillman and Spencer (since the abolition of the Malt-tax). The industry has already attained considerable dimensions, for many tons of rice and other grains are gelatinised every week. Rice is incapable of being malted by any ordinary germinating process, but when gelatinised, it forms a singularly fine and useful ingredient in the manufacture of beer. Some of its advantages are its entire freedom from the evils inevitably present in malt, for no matter how much care be given to the cleaning of barley or purification of air and water, mould-spores and germs of other low organisms are always left in malt. The conditions absolutely essential to the right growth of malt are also those most favourable to the reproduction of all such organisms. The free use of antiseptics does not entirely overcome the difficulties naturally arising from such a state of things; consequently grown malt must be always liable to this defect.

Gelatinisation effectually avoids this difficulty, for rice or any other grain which undergoes the high temperature and pressure of gelatinisation, cannot have clinging to it a single living spore or germ.

This process of manufacture resembles ordinary malting in the fact that the grain to be gelatinised is steeped and kiln-dried, the process of gelatinisation by steam under pressure being substituted for that of germination. In common malting corn is steeped from fifty to eighty hours, but by this method six hours or less suffice. It is then steamed under heavy pressure for a short time, in a closed vessel of cylindrical form, from which it passes to the kiln to be dried.

These kilns are patented, and are both novel and effective. The furnaces and encasing walls are of brick. The floors, which are of woven wire, rotate slowly over a series of drums, so that the moist corn is constantly run from the top hopper, and during its progress is robbed of moisture, and exposed to as much heat as may be desired. It is finally discharged into the bottom hopper, whence it is conveyed to any desired position for cleaning, sorting, and grinding.

It will be noticed how very greatly this process differs from common malting, and how completely it depends upon mechanical aid.

The changes produced in rice by gelatinisation are indicated by the following analyses:—

	Raw Rice.	Gelatinised Rice Malt.
Water	12·51	9·63
Starch	74·81	77·22
Dextrine and Sugar ...	1·11	2·96
Soluble albuminoids ...	0·41	0·13
Insoluble do.	8·78	8·62
Cellulose	0·76	0·33
Fat	0·78	0·43
Ash	0·84	0·71

The rupturing of the starch-granules by combined high temperature and pressure, and the essential empyreumatic flavour given by high kiln-drying in direct contact with the products of combustion, are not capable of tabulation. They, however, constitute the chief value of the process ; the points of superiority, in addition to those already enumerated, are its remarkable rapidity and certainty of action. Grain can be received, steeped, steamed, dried and ground entirely ready for use in eight hours (common malt takes from ten to twenty-one days). Every kernel, when gelatinised, is subject to precisely the same conditions of moisture, heat, and exposure, enabling the brewer to know accurately the composition of his wort, an element of uniformity impossible of attainment in ordinary malt.

All grown malt has invariably a large excess of diastatic power. Gelatinised malt is deficient in this respect, but whenever used in conjunction with common malt, the excess of diastase present in the mash-tun is invariably sufficient rightly to convert the starch of the gelatinised grain. The diastatic action naturally developed in gelatinised malt has been proved by experiments to be very distinct, and by continuing the process of gelatinisation farther it could be increased. Measuring it at the temperature most favourable to this action (150° to 152° Fahr.), it is found that about 25 per cent. of the starch is converted by the natural diastatic action of gelatinised rice, malt, and that it is a true diastatic action is shown by its being stopped by the addition of salicylic acid. The alteration in the albuminoids is evidenced by its use in brewing; for the yeast, instead of being deteriorated, as it would be by the employment of raw rice, is improved in strength.

The high pressure and heats adopted during the process of gelatinisation effectually rupture the granules of starch, making the constituent molecules enter freely into contact with the diastatic wort, which rapidly effects the change of starch into the saccharine compounds essential in worts. The peptonising influences of gelatinisation aid materially the formation of a wort duly containing the soluble albuminoids in that nice equilibrium so essential to the healthful growth and reproduction of yeast. Upon this growth the success of the brewer's operation so largely depends. The old belief in the superlative importance of fermentation in brewing has been freely questioned for some time. It is attributing causes to effects. It is now beginning to be accepted as true that fermentations are controlled greatly in the malt-house and mash-tun. The power to gelatinise such starchy grains as rice, or such nitrogenous material as maize or wheat, adds immensely to the power of a brewer to control properly his fermentation. To the general public such control has the direct advantage of improving the quality of the beer produced. Rational cultivation of the yeast is invariably and absolutely an improvement in beer, perceptible to the consumer. Consequently the sphere of malting has been speedily widened by the removal of restrictive legislation.

White Malt.

This material is also known as torrefied grain. It was invented and patented in 1883 by Mr. J. Fordred. It is barley prepared by the aid of a machine, which consists chiefly of a horizontal cylinder, surrounded by a sheet-iron casing, in which it can be rotated freely. The cylinder is made of wrought-iron plates ingeniously joined together, and there is a space between its external surface and the outside casing. Beneath the whole length of the cylinder is a long gas-burner of novel construction (also patented), which supplies a smokeless flame possessing great heating power. Inside the cylinder are a number of projecting arms, which keep the grain in a constant state of motion, and, by their peculiar arrangement, cause the stream of grain to pass gradually along from one end of the cylinder to the other. A hopper is provided at one end, with a valve to regulate the supply of grain, and at the other end is a receptacle for receiving the torrefied grain. When the machine is at work, the grain is kept in constant motion, whilst being exposed to the desired temperature, and, with a very little practice, any workman can regulate its action by adjusting the hopper-valve, the supply of gas, and the speed of the revolving cylinder, so as to obtain the desired result. By passing through this machine, grain undergoes a remarkable change; the heat, acting in conjunction with the moisture which is always present in grain, causes the starch-cells to burst, and these in their turn burst the husk; so that each corn becomes swollen and considerably enlarged. In the case of barley the original configuration of the corns is usually maintained, but in the case of maize and some other grains the corns burst completely, and take fanciful shapes, resembling parched "pop-corn." This material is used by some brewers with satisfaction, and it has been highly approved by many.*

Another form of gelatinised corn is prepared according to Southby's patent, No. 3199, August 5th, 1880, and by a later patent, No. 1269, Jan. 11th, 1884.

By the first patent, any corn is steeped for from twenty-four to sixty hours, according to the sort of corn, and the time required for it to reach the limit of saturation, which in all cases is attained. It is then transferred to the steaming-vessel, where steam at low pressure is driven through for from three to five hours. After complete cooking, the grain is removed to a kiln, where it is well-dried at suitable temperature.

When dry, the grain is ground, and is ready for use.

By the second patent (1884) provision is made to pass damp barley through smooth rolls, and so flatten it. It is then dried for several hours at high temperature, and can be used with malt in the mash-tub in the ordinary way.

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* See E. G. Hooper, Manual of Brewing, pp. 170, 175, 186; and T. W. Lovibond, Brewing with Raw Grain; the Times, Aug. 14, 1885, p. 10, Crop and Stock Prospects, &c.

Dari, Dura, or, Dhourrha *(Millet)*.

This is largely used in Africa, for the Kaffirs, Nubians, and other African races prepare an alcoholic drink from it. It is rudely malted by being covered with wet mats, and after a certain stage of growth is reached it is dried, infused, and fermented.

The Nubians term the resulting drink *bousa*, the Zulus, *huyembo*. The Kaffirs strain it through closely woven grass; but Cetewayo compared the Zulu beer to gruel.

Mungo Park describes a fermented beverage made in Africa from the *Holcus spicatus*, or wall-hardy.

Dr. Birch remarks in his notes on Wilkinson's translation of Herodotus that the propensity for intoxicating drink in the valley of the Nile may be said to augment in the same ratio as the increasing darkness of hue of the tipplers higher and higher up the valley.

The composition of dari is shown by M. G. Leeuw, who gives the following analyses in the Centralblatt für Agrikultur-Chemie for 1882, p. 484.

	Egyptian Dari.	Syrian Dari.	Malt.	Husks.
Water	10·05	9·97	8·04	5·65
Nitrogenous matter ..	7·05	9·88	10·31	3·91
Fat	6·11	3·52	4·42	0·95
Non-nitrogenous extract..	74·20	72·22	73.32	25·58
Fibre	0·97	1·63	1·77	25·80
Ash	1·62	2·78	2·14	7·98
Starch	—	—	—	30·13

Kôji.

For many centuries the Japanese have been in the habit of making a beer called *saké* with a malt prepared from rice in a way entirely different from European conceptions of malting, and without the intervention of germination, or rather without the exercise of the vital powers of the grain.

In 1881 the scanty literature of the subject was richly added to by a very full memoir on "The Chemistry of Saké-Brewing," published by Prof. R. W. Atkinson in the Memoirs of the Science Department of the University of Tokio. That part of the work relating to the preparation and nature of the kôji, or malt, was also embodied in papers communicated to the Royal Society, 1881, and to the Society of Arts, 1883, and was more or less fully reproduced in various journals.

In the preparation of kôji, the grains of rice are first deprived of the husk, then, by rude pounding, of the testa and germ. After separation of the many broken grains thus produced, the rice, now little more than 60 per cent. of its original weight, is placed in a tank and washed with frequent changes of water, the fine dust being carried off.

The grain is left in steep for a night, and is then submitted to steam till the gelatinisation of the starch renders the kernels flexible and translucent.

A microscopic section of the grain at this stage shows that it has to a great extent lost its cellular structure, the granules of starch being broken up and forming a homogeneous mass of starch-paste. When the rice has cooled down sufficiently, to about 82° Fahr., the spores of a fungus described by Ahlburg* as *Eurotium oryzae* are mixed in small proportion with the mass, which is then placed in underground chambers of practically unvarying temperature, about 80° Fahr.

Here it is alternately heaped and spread out, the temperature rising in the heaps to 105° Fahr. The malting of the grains by the mycelia is prevented by frequent manipulation, and on the morning of the fourth day the process is considered complete.

The changes induced in the rice by this method are nearly the same as in European malting; the starch is rendered soluble, and the proteins are brought into the condition of diastase, so that a large proportion of steamed rice may be used with the kôji in the brewing of saké.

It is difficult to obtain a correct analysis of kôji on account of the rapid action of the diastase upon the dextrine and starch present, the amount of dextrose increasing continually at the expense of the other carbohydrates. Temperature has, of course, an important effect upon the diastatic action as is shown by the tables given below.

Composition of Kôji dried at 212° Fahr.

		A		B	
Soluble.	Dextrose	25·02	37·76	58·10	69·45
	Dextrine	3·88		4·41	
	Ash	0·52		0·54	
	Proteids	8·34		6·40	
Insoluble.	Starch	56·00	62·22	26·20	30·51
	Cellulose	4·20		1·94	
	Fat	0·43		0·50	
	Ash	0·09		0·04	
	Proteids	1·50		1·83	
Original water		25·82 per cent.		28·10 per cent.	

Action of Hot Water upon Kôji.

Time and Temperature.	Percentage dissolved.	Percentage of Dextrose to total solid dissolved.	Specific rotatory power.
2 hrs. 120° + 18 hrs. 60°	51·8	68.0	68°
½ hr. 113°	31·8	84·9	76·1°
2 hrs. 113°	61·6	68·5	53·5°
20 min. 120°	37·2	66·0	63·2°
24 hrs. 60° + 2 hrs. 212°	49·2	58·0	73·8°
18 hrs. 40°	29·2	69·3	66·3°

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* *Mitth. deutsch. Ges. Yokohama*, heft xvi. 1878.

Composition of Dry Matter in Kôji-wort.

Time and Temperature.	Dextrose.	Dextrine.	Proteins.
18 hours at 40°—44° Fahr.	69·3	14·7	16·0
½ hour at 113° Fahr.	84·92	12·48	2·6
2 hours at 113° Fahr.	71·48	10·43	18·08

The diastase of kôji differs from that of malt in its power, which the latter has not, of hydrating maltose into dextrose. The action is so rapid that the presence of maltose can only be proved in a solution of starch and kôji by the indirect method of polariscopic examination. The inferior rotatory power of maltose causes the mixture to give a less angle of rotation than pure dextrine, and thus to afford a rough criterion of their relative amounts. But the results are vitiated by the presence of other bodies affecting polarised light. The proteids rotate the ray to the left (— 40°) to an extent varying with their relative proportion and with their condition, and some of the dextrine is converted to dextrose, which has a much lower rotatory power than maltose.

Kôji has its maximum of diastatic power at 130° Fahr., above which point it rapidly diminishes, losing all at some point between 140° and 160° Fahr. As with the extract of barley-malt, the loss of diastatic power is accompanied by coagulation of the proteids that possess it.

CHICA.

From time immemorial the American Indians have prepared a strongly alcoholic beverage, chica or chicha, by fermenting a decoction of ungerminated maize.

The corn is steeped for four or five hours, then crushed, boiled for a short time, and allowed to ferment.

The microscope[*] reveals germs of a special organism, adherent to the exterior of the grain, into which its mycelia pass in developing, throwing off vibrioles, which move freely among the starch-granules, while nucleated cells somewhat resembling those of yeast are also produced under favourable conditions. This organism can withstand the temperature of water at 95° C. (203° Fahr.) for several minutes, but is killed by chloroform. If this be added freely to the mixture of maize-starch and water, fermentation entirely ceases, unless its albuminoids have been partially changed to diastase, the action of which is unaffected by chloroform. The vibriolic fermentation is most active at 40° to 45° C. (104° to 113° Fahr.), and the immature starch-granules are most readily attacked by it, being converted into dextrine, alcohol, and carbonic acid gas (the latter coming off in torrents). The adult granules yield more slowly to the fermentative action, but give the same results.

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[*] A power of 600 to 800 diameters is most suitable for this investigation. See MARCANO, *Compt. Rend.* t. xcv. pp. 345, 346, 856-859 [1882].

The curious facts observed in the preparation of chica and kôji raise a very complex and intricate question, viz., To what extent is diastatic action influenced by mycelium or mould growth, independently of the true influences of germination? As it is proved that zymotic influence upon the exterior of grain effects a change apparently equivalent to growth, it is open to us to question how much of the supposed effect of germination is zymotic. It must be remembered that little vegetation takes place without zymotic action. The zymotic influences of kôji-preparation take place altogether independently of growth, therefore it is quite possible that the diastase of malt is partly derived from influences other than that of vegetation.

BYE-PRODUCTS.

The other products of malting are singularly few and simple. They are commonly only combes, dust, screenings, swimmings, and steep-liquor.

Malt-combes are the radicles, which become crisp and dry upon the kiln, and are rubbed or trodden off. Many maltsters keep them with the malt for the whole period of storage. Others, however, remove the dust and combes prior to storing the malt. The latter is doubtless the better plan, for the simple reason that the combes so readily absorb moisture that it is dangerous and undesirable for them to be in direct contact with the malt for any length of time.

It is not uncommon to put them upon the top of a malt-bin for a depth of five to eight inches, and they keep the malt from absorbing moisture. In this capacity they are of use to the maltster.

Their chief value is for feeding purposes. Horses, cattle, sheep, and pigs derive great nourishment from them. They are also extensively used for yeast food by the makers of yeast for distillers' and bakers' use. Careful housewives approve of them for packing hams and bacon, as they prevent undue dryness and keep off flies and other pests.

The quantity of combes produced varies largely, and depends upon the character of the barley and the length of growth of the radicles.

Thin-skinned, heavy barley of good quality, if grown with short bushy roots, will produce less than two per cent. by weight of combes—*i.e.*, 100 lbs. of dry barley will yield under 2 lbs. of combes.

Thin inferior barley, if grown fully and with great development of rootlets, will yield upwards of four per cent. of combes.

The average may be assumed roughly at about three per cent. of the weight of barley, or four per cent. of the weight of dry malt.

A great deal of attention has recently been given in Belgium, Germany, and America to the composition of combes. The investigations of Lermer are perhaps the most complete and exhaustive of any, involving the determination of a large number of organic substances, some present only in minute proportions, but not the less interesting on that account. Amongst the constituents of combes are found the following:—

ACIDS:—
- Acetic.
- Asparagic.
- Citric.
- Formic.
- Lactic.
- Malic.
- Oxalic.
- Propionic.
- Succinic.
- Tannic.
- And a fatty acid.

NEUTRAL SUBSTANCES:—
- Albumen.
- Ash.
- Asparagin.
- Cellulose.
- Cholesterin.
- Gum.
- Oil.
- Resin.
- Sugar.
- Water.
- Wax.

The relative amounts of these several matters necessarily vary greatly, not only as to such as are akin to each other, but as to substances that have nothing in common. Thus the nitrogenous matters range between eighteen and thirty-three per cent., and the non-nitrogenous bodies vary correspondingly.

The subjoined analyses are selected as typical.

	Stein[*]	Lermer[†]		Lawes[‡]		Dietrich and Konig[§]	Wolff[‖]
Water..	—	10·72	10·00	11·73	13·77	10·25	—
Nitrogenous bodies ..	30·613	32·90	18·10	23·75	22·06	24·08	19·4
Cellulose	35·686	—	—	8·54	8·41	14·27	—
Fat	—	—	—	—	—	2·07	1·7
Ash	9·245	6·91	6·91	7·41	7·82	7·17	—
Other non-nitrogenous matters	24·456	49·97	657·1	48·57	47·94	42·25	45·0

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[*] *Chem. Centr.* 1860, pp. 494, 575—578.

[†] *Polyt. Journ.* bd. clxxix. pp. 71—80 [1866].

[‡] Report on Malt for Cattle, Blue Book, 1866.

[§] Die Zusammensetzung und Verdaulichkeit der Futterstoffe, 1874.

[‖] Die rationelle Fütterung der landwirthlichen Nutzthiere, 1877.

Dust is either the very thin refuse and dirt screened from the barley, or the kiln-dust, which accumulates in kilns.

In good maltings all barley is screened prior to steeping. In some this is done prior to storing. The cleanest barley can usually be freed from some dust and fine refuse. This is of very little use or value. The quantity is ruled entirely by the nature of the barley and character of screen used. It ranges from ·05 to 3·0 per cent.

Kiln-dust is a mixture of the dust and rootlets of the barley, dropped through the drying floor, mingled with the coarser dust carried from the fire, and which settles upon the floor of the heat-chamber of all ordinary kilns.

This dust is of value for manurial purposes, and in some districts is very highly esteemed, so much as two shillings per sack, or four shillings per imperial quarter, being paid for it by farmers. Its composition and character necessarily vary very widely. If allowed to accumulate unduly, it readily catches fire, and much malt is spoiled by this means.

Screenings.—When the Malt-tax was in force, almost all barley was screened or graded, to prevent payment of a heavy duty upon corn which was comparatively of little value. On an average, about 5 per cent. by weight of barley was so removed, and was chiefly sold to millers or others for feeding purposes. A considerable quantity of this thin barley was ignorantly used by farmers for seed corn. Its value is usually from one-half to two-thirds of that of the bulk of the corn from which it was screened.

Swimmings.—When barley is run into a cistern, such refuse thin corn or other light things that have escaped the separation of the screens float upon the surface. Careful maltsters remove these swimmings, and sell them. They do not often fetch more than a shilling a bushel. The quantity is ruled entirely by the care with which the corn is screened.

Steep-liquor.

It is not usual to regard the water in which barley has been steeped as a product in the sense of being in any way valuable, and it is commonly run away to waste. But its offensive smell, developed in a few hours after withdrawal from the cistern, if not whilst in that vessel, denotes the presence of a considerable quantity of organic matters of unstable character, and microscopic and chemical tests reveal the nature of these. The subjoined analyses show that valuable mineral salts are dissolved from the grain, in association with an important amount of nitrogenous and other soluble matter. The systems, now coming into use, of thoroughly screening, brushing, and washing the corn prior to steeping, eliminate much, but not all, of the dirt, fungoid spores, &c., associated with even the best of grain.

The proportion of matter dissolved out by steeping varies with the extractive power of the water used, with the resistance to diffusion of the husk, and with the susceptibility to alteration of the constituents of the grain, whilst the amount of water used in continuous or periodical changing of the steep-liquor, necessarily affects the relative quantity of matter in solution. In any case, however, the salts and nitrogenous matter, whether much or little diluted, have a manurial value of importance where the liquor can be used for irrigation.

Drs. Hope, Coventry and Thomson, reporting to the Commissioners of Excise for North Britain, on the relative qualities of malt made from barley and Scotch bigg (1806), point out that the colouring and bitter extractive matter of steep-liquor are derived principally from the husk; for if the latter be removed the water takes up scarcely anything, and does not acquire the high colour communicated by the entire grain. That the characteristic taste and smell of the liquor are almost identical with those produced by steeping straw, and that bigg, having more husk and of a darker colour, gives a deeper tint and greater amount of extract in steeping, are further arguments in favour of this view.

The resins of the husk are probably the source of both colour and bitterness, and being more or less soluble in alkaline or neutral solutions, pass into the liquor at an early stage of the steeping. Access to the gluten-cells being thus obtained, they are partially decomposed, the phosphates set free attacking and dissolving further portions of gluten, and facilitating the absorption of moisture into the heart of the grain, and the diffusion outwards of the mineral and organic substances dissolved.

Drs. T. and R. D. Thomson, in their Report on Feeding Cattle with Malt (1846), give the following analysis of the residuum obtained by evaporation of steeping-liquor, but omit to mention the amount per gallon or to indicate the composition of the water used, except by stating that it was drawn from the Clyde and contained carbonate and sulphate of lime.

Silica	2·32
Phosphoric acid	6·22
Sulphuric acid	5·00
Carbonic acid	9·09
Chlorine	1·99
Peroxide of iron	0·72
Lime	3·95
Magnesia	4·26
Potash	29·74
Soda	23·60
Organic matter (with ·878 nitrogen) and combined water	13·11
	100·00

The nitrogen is equivalent to 5·48 per cent. of albumen, probably dissolved by the aid of the phosphatic salts. It is added that the residuum dried at 212° lost upon ignition upwards of 40 per cent., which would imply the presence of non-nitrogenous organic matter in much greater amount than shown by the above figures, and suggests serious error somewhere.

It may be noted that the amount of saline matter lost in steeping bears nearly the same ratio to the total loss of solid matter in malting as the ash of barley bears to the solid matter of the grain, proving the ash to be in chemical combination with the organic matter, and the decomposition of the latter to be a necessary preliminary to the solution of the salts.

Sir J. B. Lawes gives in his report on barley and malt as food for stock (1866) the following partial analyses (p. 40) :—

	Water before Steeping.	Steep-Liquor.
Organic matter ...	2·79 ...	265·05
Mineral matter ...	26·30 ...	155·70
Total grains per gallon	29·09 ...	420·75

The nitrogen in the steep-liquor was 8·62 grains per gallon, equivalent to 54·31 of albumen.

Lermer[*] puts the loss in steeping at

0·70 organic matter
0·34 inorganic do.

and the composition of the latter as

Potash	52·11
Soda	2·46
Sodic chloride	12·04
Magnesia	4·02
Lime	2·00
Alumina	0·04
Oxide of iron	0·08
Phosphoric acid	11·15
Sulphuric acid	4·12
Carbonic acid	9·21
Silica	2·62

whilst the relative amounts of mineral matter in barley, malt, and steep-liquor are shown by the subjoined table.

	100 Parts Dry Barley.	1·04 Parts Passing into Steep-liquor.	88·81 Parts Malt.
Potash	0·55289	0·17744	0·37433
Soda	0·02578	0·00837	0·01731
Chloride of magnesium ...	0·04646	0·04100	0·00542
Magnesia	0·15884	0·01369	0·13993
Lime	0·09000	0·00681	0·08029
Alumina	0·00973	0·00014	0·00917
Phosphoric acid	0·79297	0·03797	0·73575
Sulphuric acid	0·01411	0·01403	Trace.
Carbonic acid	0·00000	0·03136	0·00000
Silica	0·70760	0·00892	0·69861
	2·39838	0·33973	2·06081

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[*] *Polyt. Journ.* bd. clxxix. pp. 71—80 [1866].

Ullik,[*] in a series of experiments in steeping with distilled water, Elbe water, a well-water of temperate hardness, and two waters with sulphate of lime, found that all the hard waters dissolved more potash, lime, and magnesia than the distilled water, that the gypsum and the distilled water removed most soda, but the phosphoric acid dissolved was much the same with all. He holds that the duration of the steep is more important than the quality of the water.

Heut[†] finds that different barleys lose widely different amounts in the same steeping water. The variations are dependent on the ratios of bases to acids and the solubility of the resulting salts.

Michel and Handwerck[‡] find that 1 per cent. of sodic chloride has an important solvent action on the proteins, whilst it retards germination. The presence of salts of lime prevent these detrimental actions.

In the same year Mills and Pettigrew[§] published the results of a valuable series of experimental steepings of barley in distilled and in artificially prepared waters. To obviate errors they used 300 grammes of grain in 400 cubic centimetres of water, and continued the steep for seventy-two hours. The first and last experiments in Tables I. and II. were made with saturated solutions and distilled water respectively. The first column shows the percentage of salt present in the original water; the other columns that of the various constituents of the steep-liquor.

Compound A was a mixture of calcic sulphate with sodic chloride, giving the permanent hardness of the Lichfield water, and compound B was similarly made with bicarbonate of lime and sodic chloride to equal the temporary hardness of the Lichfield sample.

I.—TEMPERATURE 40° FAHR.

Carbonate of Lime.	Residue.	Ash.	Extract.	Nitrogen.
0·0896	0·4817	0·3017	0·1800	0·00364
0·0672	0·4670	0·2870	0·1800	0·00495
0·0448	0·4582	0·2830	0·1752	0·00514
0·0224	0·4440	0·2752	0·1688	0·00729
0·0000	0·4015	0·2540	0·1475	0·00635

II.—TEMPERATURE 52° FAHR.

Sulphate of Lime.	Residue.	Ash.	Extract.	Nitrogen.
0·2210	0·7240	0·4440	0·2800	0·00364
0·1657	0·7470	0·4296	0·3174	0·00411
0·1105	0·6000	0·3440	0·2560	0·00355
0·0552	0·5480	0·3400	0·2080	0·00374
0·0000	0·5110	0·2760	0·2350	0·00455

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[*] *Centr. Agrik.-Chem.* 1882, pp. 40—42.

[†] *Ibid*, p. 203.

[‡] *Ibid*, p. 486.

[§] *Journ. Chem. Soc.*, vol. xli. pp. 38—44.

III.—TEMPERATURE 40° FAHR.

Sulphate of Lime.	Residue.	Ash.	Extract.	Nitrogen.
Lichfield water* ..	0·4540	0·2427	0·2113	0·0035
Half ,, ..	0·4100	0·2207	0·1893	lost
Distilled water ..	0·4132	0·2230	0·1902	0·0042

IV.—TEMPERATURE 44° FAHR.

Compound A ..	0·4382	0·2430	0·1952	0·00299
Half A	0·4734	0·2450	0·2284	0·00435
Distilled water ..	0·4132	0·2112	0·2020	0·00322

V.—TEMPERATURE 47° FAHR.

Compound B ..	0·4528	0·2372	0·2156	0·00325
Half B	0·2350	0·2350	0·2280	0·00400
Distilled water ..	0·4334	0·2274	0·2060	0·00392

Phosphates were found in all the liquors. In Series I. the liquor was slightly acid, and gave a precipitate on boiling, the filtrate from which was not acid and contained no phosphate. In Series II. alkaline sulphate was found; less and less colouring matter was dissolved as the amount of gypsum was increased, and the saline liquor gave far less precipitate when boiled than the pure water extract. From the latter an albuminoid precipitate is produced in the cold by metaphosphoric acid, and the filtrate gives a further precipitate on boiling.

The authors conclude that the Lichfield water, so esteemed at Burton for steeping purposes, owes its value to the nitrates it contains. Gypsum and chalk if concentrated remove a greater total of organic matter; if dilute, a greater amount of proteins; and in either case more mineral matter than pure water.

In 1884 Behrend and Stürcke published in the Wochenschrift für Bierbrauerei a communication from the technical laboratory of the Agricultural Academy of Hohenheim on the chemistry of malting, a translation of which appeared in the Brewers' Journal in the following year. In this article it is shown that the loss of phosphates in steeping, which has a serious effect upon the yeast, is affected by the duration and temperature of that operation, as well as by the character of the water and the size of the kernels. The results of the experiments, condensed and converted to British measures, are as follows:—

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* The Lichfield water had the following composition:—

Nitric nitrogen ..	0·393 parts per 100,000.		
Silica	0·656	Hardness (temporary)	7·070.
Magnesia	1·412	,, (permanent)	11·100.
Lime	10·034	Carbonic acid	3·0211 volume per cent.
Sulphate (SO_4) ..	4·450	Nitrogen ..	3·4747
Chlorine	1·950	Oxygen ..	3·1080
Total solid	32·440		

Analyses of Steep-Liquor.

Barley.	**Saal.**			**Bohemian.**			**Hungarian.**			**Average.**		
Grains per Gal.	**Dry Matter, viz.**	**Organic.**	**Inorganic.**	**Dry Matter, viz.**	**Organic.**	**Inorganic.**	**Dry Matter, viz.**	**Organic.**	**Inorganic.**	**Dry Matter, viz.**	**Organic.**	**Inorganic.**
1st Steep (14 hrs.)	277·198	131·460	145·738	314·520	148·998	165·522	430·247	205·017	225·230	340·655	161·825	178·830
2nd „ (24 „)	93·486	42·395	51·091	114·213	45·946	68·267	138·272	75·224	63·048	115·324	54·522	60·802
3rd „ (24 „)	51·454	37·032	14·422	55·584	42·612	12·972	59·135	39·206	19·929	55·391	39·617	15·774
3 Gallons.	422·138	210·887	211·251	484·317	237·556	246·761	627·654	319·447	308·207	511·370	255·964	255·406
Average per Gal.	140·712	70·295	70·417	161·449	79·185	82·254	209·218	106·482	102·736	170·456	85·321	85·135

PART III.—BUILDINGS AND TOOLS.

CHAPTER XIII.

CONSTRUCTION OF BUILDINGS.

Maltings. Construction of Buildings:—

Malt-houses. Malt-stores. Barley-stores. Construction. Growing-floors: Tile, Slate, Cement, Glass. Lighting: Gas. Cisterns: Iron, Brick, Slate. Valves. Kilns: Furnaces, Air, Roof, Outlets, Double Floors, Cowls, Tomkins' Kiln, Farcot Kiln, Blackman Fan, Wheelwright's Kiln, Geomen Kiln, Toepfer's Kiln, Seagrave's Kiln, Gillman's Kiln, Stopes' Kiln. Elevators. Conveyors. Roof. Drying Floors. Wire. Tiles. Horsehair. Baffle-plates. Furnaces. Air Kilns. Turners: Schlemmer's, Perry's. Malt-stores.

ALL malt is prepared commercially in buildings more or less exclusively devoted to its manufacture. These consist of malt-houses (or maltings), malt-stores, and granaries.

Malt-houses are variously constructed for the differing systems of making malt within them. Thus we have four sections into which it is convenient to divide this subject:—

(A) The ordinary English and Continental systems of malting.

(B) Pneumatic malting.

(C) The manufacture of black, amber, crystal, and other special malts.

(D) The gelatinisation of rice or maize, and other processes of preparing grain for brewers' use.

The English system, briefly, is steeping corn in an open vessel, germinating it upon flat, exposed floors at very shallow depths, and drying upon an open fire-kiln with single floors at from nine to twenty-one days after steep.

The Continental system differs in steep, position, and depth of floors, time, and mode of drying.

Pneumatic malting implies absolute control of the conditions of the air supplied to growing grain, and its consequent modifications of growth.

All maltings belonging to sections A, B, C, and D have only two things in common: they must all be able to receive and moisten grain, and finally dry it. All malt-houses belonging to sections A, B, and C have this further in common—they must secure conditions more or less favourable for the proper germination of corn up to a certain limit, prior to the drying process and within a given range of temperature.

These conditions are all subject to definite limitations of heat, and of circulation of air. Simple as they appear to be, they present scope for an almost infinite diversity of arrangement of building and modes of construction.

Coupled with the due consideration of solidity of building and economy of labour, they cover the whole sphere in which the engineer can serve the maltster, or, in other words, they embrace the whole of the engineering of malting.

A sufficiently clear outline will be given here to be chiefly of practical value to those men who design and erect their own buildings.

The simplest form of malt-house possessing any capacity for work is a plain two-story building, having attached to it a kiln or drying-house, and consisting of a ground-floor of clunch, a brick steeping-cistern, and a first-floor of timber, with or without partitions for separating the stored grain or malt. The only implements are a wooden shovel, and a winnowing fan or sieve to separate the roots or "combes" from the malt prior to its use in the brewhouse.

Houses of this class were at one time extremely numerous, and a great number still exist. Their cost of erection is very moderate, so low that it is still customary in those counties where such malt-houses abound, to charge an annual rental of 20s. per quarter steeped, *i.e.*, a house capable of steeping twenty-five quarters, commands a rental of £25 per annum. Thus houses of this class should cost under £20 per quarter for erection, including value of site, and even at such a prime cost, would be as bad an investment for the building owner as they are, commonly, to the maltsters working them.

Malt making is to be seen in Italy in an open court or *loggia*, where the barley is steeped in a tub, allowed to germinate upon the stones in the open air, and dried in a small lean-to building, with only a hole in the roof for the exit of smoke and vapour. This is furnished with a floor of perforated sheet-iron and a furnace similar to that used under an ordinary washing copper in an English scullery.

Even more primitive operations are performed in Nubia, as there millet is dried in the sun.

Such rude malteries concern us only so far that they occupy the lowest end of the scale, and indicate the necessity for moisture, growth, and curing or drying, the three essential conditions of making malt.

The antithesis of these houses is the grand malt-house of M. Bonnette, of Troyes, illustrated (pp. 227—231).

The vast diversity of buildings filling in the various grades of the long scale, of which these form the ends, are of use to a maltster or to the engineer, who knows them all sufficiently, to direct him in the scientific appreciation of his duty when called upon to construct a malting, to devise the machinery, to minimise the labour of its working, or to invent and construct such apparatus as shall absolutely control the conditions of the material treated, throughout the whole of the period that it is in the building.

The best description of building for any malt-house is a combination of stone, brick, concrete, iron, and timber, as each of these materials possesses advantages special to itself for the particular purpose to which it is adapted; nevertheless, numerous other materials can be used.

A malt-house may be constructed in almost any position, and of nearly every form that may appear to suit special sites. A right consideration by the architect or engineer, when he is in a position accurately to estimate the force and true value of the conditions which have been specified, would prevent the absurd and wasteful structures that can be so frequently encountered in all parts of Europe, in which malt of an inferior character is necessarily manufactured, owing to the impossibility of maintaining, throughout the somewhat lengthened process of making malt, all or perhaps any of the essential conditions.

A good malt-house of fair size belonging to section A is most conveniently and favourably worked if it consists of one main building of three stories—two kilns, and a corn or malt store. If adjacent to a brewery or distillery, the basement may be used as a cellar or bonded warehouse, and power may either be taken from the brewery- or other engine, or (preferably) steam may be conducted from the boiler of the brewery to a small separate engine fixed in the malt-house. If the building is isolated, then a small and separate engine and boiler are desirable.

Power is of little real utility in any malting of this class steeping less than 400 quarters per month. Those steeping from 400 to 600 quarters per month can conveniently be worked by a gas or hot-air engine, but every malt-house steeping 800 quarters and upwards per month should possess steam power.

Every size and description of malting belonging to sections B, C, and D should have power, preferably steam, although some very large houses are worked by manual labour.

Under certain favourable conditions, water-power is applicable, and it is lamentable to find in how very few cases it is utilised. Hitherto, engineers have been called almost exclusively to advise upon and construct the motors in maltings, and the appliances for cleaning or moving grain. The day has at length dawned when their opinions and advice are recognised as of distinct value in other departments, more particularly as to the best modes of securing and rightly maintaining the conditions already set forth as necessary. It is, therefore, to be hoped that an industry, which, in our land, has remained almost stationary for several centuries, will feel the quickening impulse of well-trained scientific thought directing its operations, in preference to the rude empirical measures that until so very lately pervaded it.

SECTION A.—ENGLISH MALT-HOUSES, OLD PLAN.

Malt-houses of this class are very rarely built of a size smaller than what is technically called fifteen-quarters steep, *i.e.*, they steep or wet, every three and a-half or four days, fifteen quarters of grain, which gives a capacity of 120 quarters per month of malt made. As houses of this character usually work for only seven or eight months, their total capacity falls short of 1,000 quarters per annum. In many cases houses of this size are worked entirely by one man, who, for the four summer months, commonly follows some other craft, such as thatching, bricklaying, or the like. When malting commences in October, his duty is to receive the barley, screen, and pass it into the cistern, steep, couch and floor it, raise to the kiln and dry it, tread, screen, store, again screen it, and measure into sacks for use. All this, involving constant attention, skill and care, is performed for the wage of from 14s. to 20s. per week, or say from £28 to £40 per annum. The value of the malt made on an average would be over £2,000. The difference in value of such malt if well and intelligently made or carelessly attended to and spoiled, would be from £200 to £500 or more, without reckoning the loss in quality of the beer, &c., produced. To prevent such damage and loss, and to procure the greatest aid to perform properly these arduous and onerous duties, it is necessary to see to the following points:—

The house should be of strong solid construction, and consist of two floors, or, if space is limited, of three floors and a kiln. The shape and size are always ruled by the position of the house and the nature of the site, but they should rigidly follow the relative proportions that experience has taught to be the best for the purpose of making malt; that is to say, the length of the growing-floor should always exceed the breadth by at least two to one.

The capacity of the growing-floor is the true gauge of the power of the malt-house, and every measurement of all other parts should be calculated solely upon such capacity. A fifteen-quarters house should never have less superficial area of combined couch- and floor-room than 2,600 feet if in the south of England, or 2,400 feet in the north of England or Scotland, unless any exceptional condition of altitude or position affect the mean annual temperature of the floor, when the skill and knowledge of the engineer would regulate the areas by such information and data as he could secure or observe.

A seventy-five quarters house is the largest that can be properly worked upon the English system unless there are three growing-floors, although some of much greater size are working with results that are supposed to be satisfactory. The capacity of such a house is 5,000 quarters per season. The proper area of growing-floor for seventy-five quarters every three and a-half days is not less than 12,000 feet, and in a house with two floors it follows that both must be 120 feet by 50 feet.

Any malt-house working upon this system with floors of greater breadth than fifty feet labours under defects which ere long will be considered fatal, for it is difficult, if not impossible, rightly to regulate the temperature of the corn, or the access of fresh air. There are also structural difficulties, which become serious defects in those cases where imperfect or erroneous calculations have been made of the strain produced when such a house is fully laden.

It cannot be too often impressed upon all connected with malting in any way that one of the prime factors in making good malt is heat, and the manner in which it is communicated or absorbed from grain. The other great factor is the air, both in its quantity and quality. Light has comparatively little influence; consequently, if a floor is too wide it is simply impossible to control the air-supply or, indeed, regulate the heat with the accuracy and uniformity requisite to produce malt in the best manner.

Throughout the whole of the earlier portions of the processes of malt-making it is always most important to secure a right supply of cool moist air to the corn in steep, couch, or for the first seven to ten or more days of its growth on floor. In small maltings, this can only be done by regulation of doors, windows, and shutters; and the same means are used also to assist in the regulation of temperature. In fact, these agencies, coupled with the shovel and the particular construction of the house, are the only ones employed in the vast majority of maltings of all sizes to regulate or control the two chief conditions of malt-making.

When convenient and practicable the growing-floor should be below the natural ground-line of the adjacent soil in order to secure uniformity of temperature. The idea has struck many minds of having a double floor, the upper one of some porous material, perforated so that ready circulation of air may be secured, and a discharge of the carbonic acid gas generated by germination. It is now being worked or successfully experimented upon in several places. This question is one of great interest and importance.

Mr. Flinn (Bishop's Stortford) has experimented very successfully upon this subject, and has patented his inventions in connection with it.

Mr. J. Madocks, of Dartmouth, has also worked an ordinary malting with a second, perforated metal floor fixed twelve inches above the old tile floor. This has acted admirably.

The growing-floor may be of many materials, for quite a diversity of floors are used—probably tiles are most esteemed; then cement concrete worked to a good face; slate, brick, asphalte, clunch, or a mixture of chalk and gravel rammed to a hard level surface; York or other hard stone set in cement; perforated sheet iron, and iron tiles; glass, and wood.

The preference for hard well-baked or unglazed earthen tiles is one which must be more or less erroneous. Their supposed merits of absorption, and subsequent supply of moisture, and of forming a soft bed for the grain, are direct evils capable of demonstration. They present favourable conditions for the spread of deleterious organisms, and for this fact alone, if for nothing else, should be regarded with suspicion.

Commonly, also tiles are improperly laid, and as a result the surface of the floor is irregular and uneven. As a consequence, when the young floors are turned or ploughed, some grains are generally squeezed or broken.

Glazed tiles have this defect to a greater degree than the porous kinds, and they have not the supposed virtue of porosity.

All tiles, if used, must be laid diagonally, and should be set in cement with great care. Attention should be given to their thickness and density.

The form of floor to which the least objections are urged is Portland cement. If this material is good in itself, and rightly mixed and prepared, it decidedly forms the best floor yet in common use.

Portland cement to be good should weigh not less than 110 lbs. per strike-bushel (imperial). It should not be stale or old. When passed through a sieve having fifty wires per lineal inch (2,500 meshes per square inch) not more than twelve per cent. by weight should be detained, and it is better if ninety per cent. passes through the sieve. It ought also to stand, without fracture, a tensile strain of at least 300 lbs. per square inch, within ten days after mixing.

Any cement which possesses these qualifications can be mixed with finely broken brick or burnt clay, clean, sharp, small, well-washed ballast and sand, and sufficient clean water to make a concrete of fair consistency, with the result that a splendid floor can be secured. Great care and skill are needed to procure and select these materials and apply them.

If the cement is inferior in any point, if any of the other materials are dirty or otherwise imperfect, if they are used in wrong proportions, or if they are not worked up truly and properly before setting, an imperfect floor must be the result.

A bottom floor can be any thickness, exceeding two inches, that the circumstances of width and nature of soil require.

An upper floor should invariably be upwards of four inches thick upon close-lagged centreing, which should remain permanently, if the particular construction of the floor permits it.

Slate.

This material is often used for growing-floors, particularly upper floors. It is generally fixed in large thin slabs resting upon wood bearers. Frequently the thin slate is left bare on the underside, without packing or lagging. As a consequence, it is terribly sensitive to fluctuations of temperature. Even if thick slabs are used, and they are well lagged with wood, clay, or concrete, they do not make as good a floor as cement, and are more susceptible to differences of temperature or humidity. Germination necessarily suffers from these differences.

Brick.

Brick floors have all the faults of tiles, and in most cases are less desirable than either tiles or slate. Thin bricks, laid flat, have inevitably an irregular surface, filled with cracks, and they cannot, as a consequence, be kept clean.

Asphalte.

Many varieties of asphalte have been tried for floors, but rarely with much satisfaction or success. For some reason difficult to understand, barley grows irregularly upon asphalte, and has a tendency to develop the plumule improperly. Young floors also mat together with greater celerity upon asphalte than on any other floor. Were it not for these defects it would be equal to cement for smoothness, cleanliness, and general utility.

Clunch.

In chalk districts, floors are often formed by mixing small ballast or gravel, and chalk, and ramming it to a hard smooth face. Although in some cases this seems to give satisfactory results, especially when sprinkling is properly understood, this mode of making floors cannot be recommended in new malt-houses.

Stone.

York and other hard stone is occasionally fixed for floors. In most districts the cost would preclude this material. Otherwise, provided it is truly and properly laid, there is little objection to its use. It requires to be set in cement, and should always be laid diagonally.

Iron.

Cast-iron tiles and sheet-iron plates have been occasionally tried, but with very unsatisfactory results, excepting in those cases where a double floor is used, with an air space between the true floor and the growing floor.

In this position, perforated iron sheets give very excellent results. Mr. Madocks, of Dartmouth, has used a floor of this description for several years, and the corn has grown better than upon an adjacent cement floor.

Iron is too good a conductor of heat to be employed as a single floor.

Wood.

Probably wood is the very worst material of all for floors. Frequently in houses possessing two floors, the upper one has large wooden flaps or doors for the ready raising of the grain. The difference they cause in the growth is clearly perceptible in many cases. The less wood is employed on growing-floors for any purpose, the better in every way.

Glass.

An improved form of glass has been invented by Mr. Siemens. This is as tough, hard, and cheap as cast iron. It has not hitherto been employed upon malting floors; but it would form an admirable substance to demonstrate fully and conclusively whether or no an absolutely non-absorbent substance is favourable or otherwise to the proper germination of barley.

In the construction of floors it is always desirable to make them rounded, and possessing a sufficient fall to enable proper flushing and scrubbing to be frequently effected.

Floors are made entirely of iron, wood, brick, and concrete, in many combinations, of which the following cuts are illustrations:—

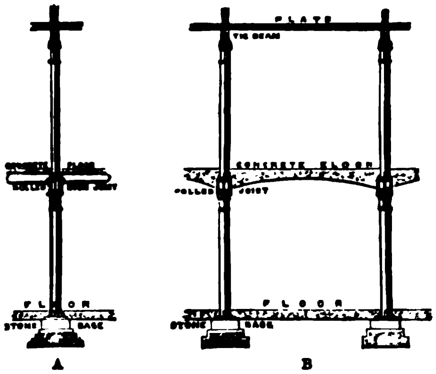

FIG. 8.

A. This is an economical plan of construction. By it the weight of upper floors is kept entirely and directly upon the columns. The underside of the concrete is kept flat, and the sustaining irons are completely embedded in the concrete.

By the plan B the main joists are embedded, and no cross-irons or carriers are used.

The relative cost of iron or concrete rules the economy of one plan over the other. Neither plan is applicable to all circumstances, and numerous other methods of construction are followed.

Upon the Continent it is very usual to find the growing-floors entirely below ground, and vaulted over, forming deep cellars. Care is taken to renew their air, and they are usually kept scrupulously clean and cool.

Lighting.

Ford says:[*] "Windows should not be glazed (let the colour "of the glass be what it may), but plain, well-made louvre-"boards to fit quite close. The advantages of louvre-boards

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[*] FORD: Malting and Brewing, p. 36.

" are that you can regulate the supply of light and air to any " degree required."

Scamell says:* "The window openings should be fitted with " shutters, and should be made to slide, and not hang with " hinges. Opinions differ as to whether the openings should " be fitted with glass; but, on the whole, it appears desirable, " as the temperature can be better regulated than when " shutters only are provided."

The best thing is a combination of louvres and glass, with shutters sliding at the backs of frames. The glazed centre is best hung upon the sill of the frame with butt joints, so that it opens downwards, sloping towards the roof. By these means any required combination of air and light can be secured, whilst the temperature and ventilation can be adequately and properly controlled.

The colour of the glass can be either blue, white, or yellow.

If gas is used it should have fixed burners, that cannot be shifted. A powerful reflector should be placed behind each light to direct the rays in the required direction, and surmounted with conical receivers to catch all fumes and heated air, conveying them by a small pipe through one of the external walls.

Gas is a bad artificial light, and the less it is used the better, as it gives a larger proportion of noxious fumes and vapours as the products of its combustion than any other of the ordinary sources of illumination. These prejudicially influence the green or germinating corn. Candles are better, but unsafe, and the dropping of the tallow amongst the corn is very undesirable.

Paraffin- and oil- lamps have obvious disadvantages, and should never be used.

Undoubtedly the best is the electric light, but it is applicable to large maltings only, so long as we are depending upon those methods of producing and regulating electric lighting yet discovered.

Cisterns.

All malt-houses should have at least two cisterns, which should always be at the end opposite to the kiln in a single-floor house, and in a two-floor house at the kiln end, so that labour may be saved. These should invariably be so placed that entire control of the temperature of the steep liquor can be secured, as temperature has great influence in starting growth, and be so arranged that corn can be readily screened into them when filled with water to enable the thin corn and refuse to float off. The water must also have command of them, so that it can be run in from below, and overflow at top, prior to a change of steep-liquor, or at any time during the continûance of steeping, and a number of inlet- and outlet- pipes, all fitted with strainers, should be fixed. They should possess in addition a series of perforated pipes, by means of which water can be sprayed or sparged over the corn like a shower upon the whole surface in equal volumes.

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* SCAMELL and COLYER. Breweries and Maltings, p. 108.

The construction of the cisterns should be such that the disagreeable labour of emptying by shovels should be obviated, for the grain is quite capable of running down to the growing-floor if the cisterns are rightly placed. (See Fig. 9.)

Cisterns are made of iron, slate, and brick.

Formerly many restrictions upon size, shape, and position existed. As these are now all removed, we can disregard them altogether, and adopt that shape, material, and position best calculated to do the work rightly.

If a malt-house is worked upon the old plan of steeping once every four days, or three times a fortnight, one cistern suffices; if the Stopes' system is adopted—two cisterns are necessary.

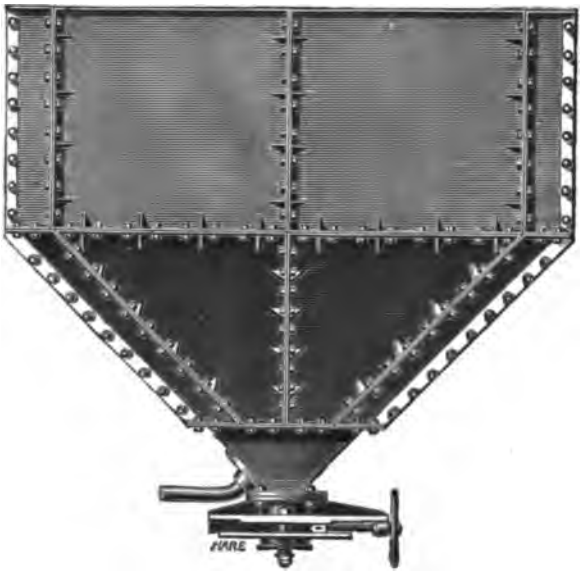

FIG. 9.—STEEPING CISTERN, STOPES' PATTERN.

Upon the Continent a number of small wrought-iron cisterns are generally used. This is an excellent plan when the different growths of barley are kept separated, as each sample of corn can have just the length of steeping it requires. When corn is mixed this is no longer necessary.

Square cast-iron cisterns possessing conical bottoms (see Fig. 9) are best. These should be made of ample dimensions to admit of variations of dryness and size of barley from season to season.

Their capacity should invariably be ample to steep the utmost quantity of corn the floor can possibly grow in the coldest weather. Not less than fourteen cubic feet per quarter steeped should be allowed when calculating their dimensions.

The great majority of existing malt-houses have one brick cistern built at one end upon the ground-floor. These are very generally rendered in cement, and provided with a wooden or stone curb in front. Some have leaden coverings or protecting aprons to the front wall.

If new cisterns are built in brick, it is desirable to use white glazed or enamelled bricks, set in neat cement, with fine, well-struck joints.

Old cisterns are generally shallow, with a good margin of depth to admit of swelling of grain, &c. If, in dividing them to make two cisterns, the capacity of the two is less than the growing-floors or kiln can work properly, little objection can be raised to heightening the walls to such a point as may be requisite.

The cross wall should be built in cement, and care must be taken to tooth or tie it securely to the sides of cistern. An excellent form of construction is afforded by use of the "Hygeian Rock" building composition. Where space is of great value the construction shown by Fig. 10 is useful. This gives a wall of sufficient strength for cisterns of common width, and occupies nine inches only of the steeping capacity. This construction is strong enough for nearly all cisterns.

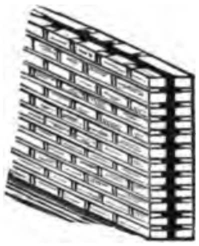

FIG. 10.—MODE OF USING HYGEIAN ROCK CEMENT.

It is claimed for this material that it is damp-proof; it requires no skill to use, for its application is so simple as to be within the comprehension of any labourer of ordinary intelligence, and by its use great economy can be effected.

The great strength given to masonry or brickwork by this material is indicated by the following experiments:—

A nine-inch brick beam, four courses high, six feet long, with four and a-half inches bearing at each end, was loaded *in the centre* with 1 ton 1 cwt. 3 qrs. 3 lbs. before fracture.

In another case a fourteen-inch beam of the same length, height, &c., and same bearings, carried 2 tons 1 cwt. 3 qrs. 3 lbs. *in the centre* without exhibiting the slightest sign of fracture or deflection.

Each of these beams had suspended 6 cwts. and 12 cwts. respectively for a fortnight previous to testing.

Slate is more rarely used for cisterns, although it is an excellent material for the purpose, particularly if lagged, or otherwise protected against variations of temperature.

Nearly all existing cisterns are constructed so that no provision is made for regulating the supply of air to the corn when steeping, or the temperature of the liquor when applied or during the steep.

These points are too important to be left to chance. It is also desirable to have the liquor renewed during steeping, by sparging or sprinkling over the top in a fine uniform shower, in preference to running on or under in a considerable stream.

Brick or concrete cisterns should have a wide central channel, running their full length. The top of this channel must be framed to receive perforated iron plates, or tiles, to serve as strainers. Where both cisterns run into one outlet or drain, a pipe from one cistern can be laid along the bottom of the channel in the other cistern.

In the arrangement and construction of a cistern, all the above points and details require careful attention to secure the best results.

Several kinds of valves are used for discharging cisterns, but none seem so simple as that shown in Figs. 9 and 11, designed by me.

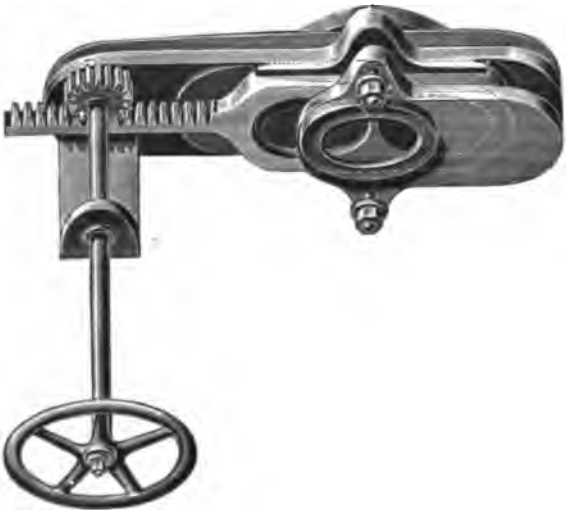

FIG. 11.—DISCHARGE VALVE FOR CONICAL STEEP. STOPES' PATTERN.

For a large malting a storage cistern or tank should also be used, of sufficient capacity to equal at least two or three steeps. This should be fixed at a proper altitude to command the cisterns and growing-floors for sprinkling and washing down.

If a separate engine- and boiler-house is built, such a tank conveniently forms its roof, and it is an excellent device to utilise the waste- and exhaust-steam to raise the temperature of this stored liquor in very cold weather. For sprinkling and steeping, such warmed liquor is of considerable value and utility.

Couch-Frame.

A great deal of time has been spent by legislators to determine the right size, shape, and position of the couch-frame. During the collection of the duty the couch played a very important part. Happily this is ended, and it is now contended by some that the couch is no longer of use or necessary.

No frame for couching need now be built or fixed, if it is objected to, but it is certainly desirable to keep the grain heaped as in couch for a certain time before opening-out on floor, as exposure to the atmosphere is neither necessary nor desirable at this time.

If a couch-frame is built, the old plan of placing cleaned-up deals or stout wrought boards in grooves formed by splines affixed to walls, or cast in columns, is sufficiently good for all practical purposes.

Kilns.

Comparatively little differences of size, form of construction, or use, occur in all ordinary malt-houses in the cisterns, couch-frame, or floors.

The kiln or drying-house is a building in which the conditions are of an exactly opposite character to those we have been hitherto considering, and the construction of kilns has offered, for ages, many diversities of form and use.

Heated air is called upon to dissipate and remove so much of the moisture as can practically be removed from malt, to stop growth, and at the same time to impart characteristic flavours and influences. These concern the brewer chiefly, but the maltster should have sufficient knowledge of them to enable him to guard against the errors to be witnessed in so many places.

Kilns should also be used for sweating or drying barley prior to steeping.

Briefly, the kiln should ever be a lofty and roomy structure, preferably of brick, with a high roof surmounted by a cowl. Its area of drying-floors should never exceed one-fourth, or be less than one-sixth of the growing-floors, nor should the combined air-inlets and discharges ever bear a ratio to each other exceeding that of four to five. Inattention to, or ignorance of, this simple fact on the part of many kiln-builders has caused an enormous waste of fuel, and damaged immense quantities of malt.

The mode of construction of furnaces of kilns may vary widely, and upon the form depends the area of grate-surface.

The drying-floors should be two in number, placed at a suitable distance apart. The lower floor should have its distance from the furnace regulated by the construction of the house—and the nature of the malt desired to be produced. In altering old kilns, I have had opportunities of trying all heights, ranging from 5 ft. 6 in. to 27 ft. In new kilns, the right limits are from 12 ft. to 18 ft., somewhat ruled by utilisation of the kiln as a malt-store. No fixed rule for the regulation of this height has yet been formulated.

The materials with which kilns have been constructed, almost equal in diversity the variations in form employed. In fact, a large volume could be written about kilns alone, if attention were paid to the numberless minor differences that still exist, or have been tried, at various times during many centuries.

The subject of drying malt is treated at another place (Chap. XX.). Accordingly, we at present confine our attention chiefly to the construction of the kiln.

Ordinary furnaces must be constructed to work properly and economically in such a way as to burn rightly the fuel generally used. The numerous varieties of fuel take differing volumes of air. Muspratt* states that 1 lb. of peat requires for complete combustion 134 cubic feet of air at 66°; peat charcoal from 155 ft. to 228 ft.; brown coal (lignite) 139 ft. to 220 ft.; ordinary coal varies from 170 ft. to 280 ft. Richardson gives still greater quantities of air; and Regnault† states that 1 lb. coal requires 320 ft. to 332 ft. of air; 1 lb. coke, 194 ft. to 250 ft.; 1 lb. anthracite coal, 233 ft. to 277 ft.

One of the most common defects in kilns is the want of air-inlets. No provision is made, in many cases, for any supply from the outside, and all that reaches the fire is drawn over the floors, or finds its way through cracks and crannies, furnished by badly-fitting doors and windows, &c.

The theory of chimney-draught, by Mr. W. Barnet le Vau‡, is applicable to the air-currents in kilns when properly constructed. Kilns with large outlet-openings have naturally the upward air-flow materially interfered with.

"The upward movement of warm air and gases of combustion
" in chimneys is caused by the difference in density of the
" external air, and of the enclosed gases. All permanent gases
" expand 0·0020284 (or $\frac{1}{493}$) of their volume for each degree
" Fahr. of difference in temperature, starting at 0° C., or
" 32° Fahr., and the density in weight per unit of volume
" decreases as the volume increases—that is, if the volume is
" doubled the weight per unit of volume will be only one-half
" of the original weight. Suppose a tube to be of one square
" foot area of cross-section vertical and 100 feet high, filled with
" air of the same density and temperature as that surrounding
" it, the air-pressure will then be in equilibrium inside and
" outside of the tube, namely, 14·7 pounds to the square inch,
" or 2116·8 pounds to the square foot, which is the pressure at
" the base. All gases exert pressure equally in all directions,
" so that the downward pressure of the air at the bottom
" of the tube is balanced by the upward pressure of the sur-
" rounding air, and no motion will ensue. The weight of a
" cubic foot of dry air at 60° Fahr. is 532 grains; or the
" air in the tube (100 cubic feet) would weigh 53,200 grains, or
" 7·6 pounds—that is to say, the pressure per square foot at
" the top of the tube would be only $2116·8 - 7·6 = 2109·2$
" pounds, the force with which the enclosed air presses upwards
" at the top, and is balanced by the pressure of the air above,
" so that no motion will ensue. Now let us heat the air in
" the tube from 60° to say 360° Fahr., a difference in

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* Chemistry, vol. ii. p. 15.

† *Annales des Mines.*

‡ *Proc. Franklin Inst.*

" temperature of 300°. The enclosed volume of air will be expanded to

$$1 + 300 \times 0{\cdot}0020284 = 1{\cdot}60852 \text{ volumes.}$$

" The actual volume in the tube is 100 cubic feet expanded to 160·852 —that is, 60·852 cubic feet will be ejected from the tube by the force of expansion of the heated air, but the weight of the remaining 100 cubic feet of air in the tube will be only

$$\frac{7{\cdot}6}{1{\cdot}60852} = 4{\cdot}714 \text{ pounds}$$

" or 7·6—4·71=42·886 pounds less than the upward pressure of the surrounding air at the base. The heated air in the tube will consequently be set in motion upwards by this motive force of 2·886 pounds by the cool air entering under the base. This is the principle upon which the so-called 'draught' is generated in chimneys, which in reality is no draught, but a pushing of the cold air under the fire-grate, by expansion of the heated air which drives the mixed gases of combustion up through the chimney. In our first illustration the cold air from underneath the tube will soon drive out the heated air and establish an equilibrium of pressure by which the upward motion is stopped. But in a furnace the enclosed air and other gases are continually heated, which results in a continual motion upwards in the chimney."

In practice it is found that the more closely a kiln resembles a chimney in construction, the greater is its effective capacity. Consequently the tendency has been constantly to increase height of kilns. Had kiln-builders seriously considered the conditions involved, and had they a mere smattering of knowledge of the laws ruling those conditions, we should not find so great a number of absurdly imperfect kilns still working.

Kilns are constructed of many forms. A large kiln is best square, or at least rectangular. Small kilns can be circular, but there are several material objections to a round kiln without a corresponding number of advantages.

Fig. 12 is a type of kiln very common in Great Britain. It is sometimes constructed of brick throughout, including the roof. More commonly it has a tiled or slated roof, lathed and plastered inside. The furnaces of a large kiln are numerous. A small one has but one furnace.

These are of the simplest type, being merely two plain walls arched over, and carrying wrought iron bearers supporting the fire bars. Frequently the regulating draught-holes (F) are not built in. The dunge (G) is occasionally made of concrete, and is used as a coal-hole or fuel store. The baffle-plate (D) is commonly iron, but it is not unusual to find it of tile, or even clay, tempered upon a small square of old woven-wire floor. Generally kilns of this class have far too many windows and doors (H). The floor (C) is built at all heights, ranging from five feet to twenty-nine feet above the furnace, and is of tile, iron plates, wire, or horse-hair. The cowl (A) is very common to kilns of this class, although many kilns are covered, as Figs. 13 and 14.

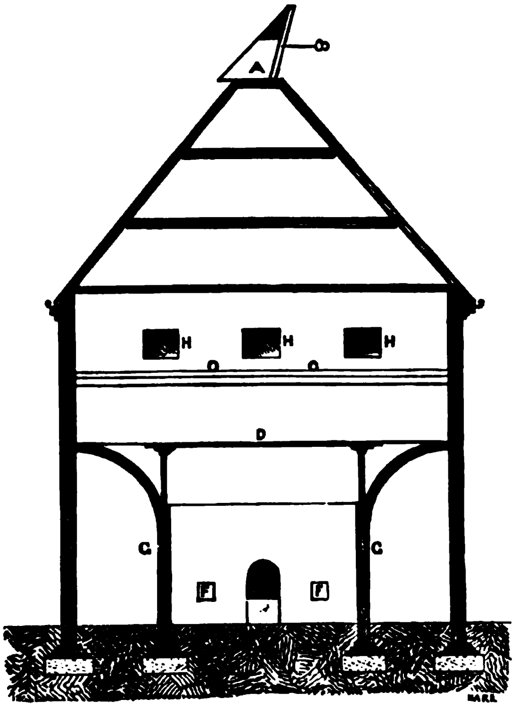

Fig. 12.—Kiln, Common Type.

Many others are left quite open to the air, as Figs. 15, 16, and 17.

Ford says* that the cupola with louvred boards is most imperfect, and modern practice quite confirms this. Many kilns are still working which are quite as bad as the case cited by him.

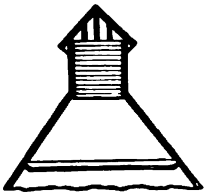

Fig. 13.—Louvre Outlet to Kiln.

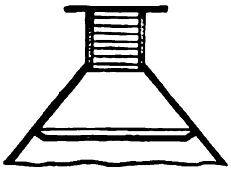

Fig. 14.—Flat Mushroom Top to Kiln.

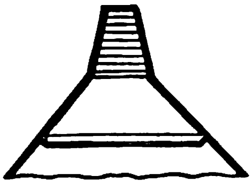

Fig. 15.—Open Outlet.

Some, as in Fig 17, have a circular opening six or seven feet across entirely uncovered.

[*] Practical Treatise on Malting, p. 140.

All kilns of this class were originally built with one drying-floor only. A number have been altered to the Stopes' system with considerable benefit.

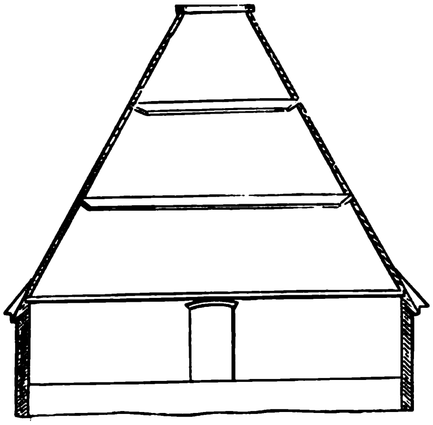

FIG. 16.—OPEN-TOP KILN.

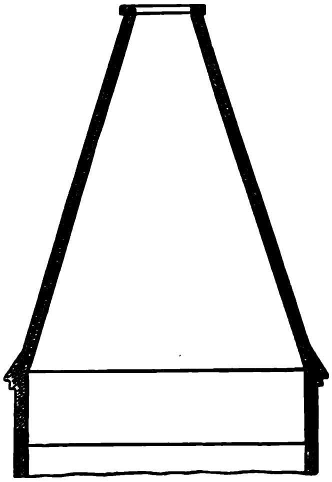

FIG. 17.—OPEN CIRCULAR BRICK KILN.

No kiln for drying malt had been built in Britain with two drying-floors until 1881, when the first was tried successfully at Brighton by Messrs. Tamplin and Sons, and almost contemporaneously another was erected at Bishop's Stortford by Mr. Flinn. Another kiln was designed and built by Mr. Tomkins, for drying maize, &c., with two floors, which, curiously enough, was done in entire ignorance of the other two kilns, nor had Mr. Tomkins seen a two floor-kiln upon the Continent. Double kilns have been largely used for many

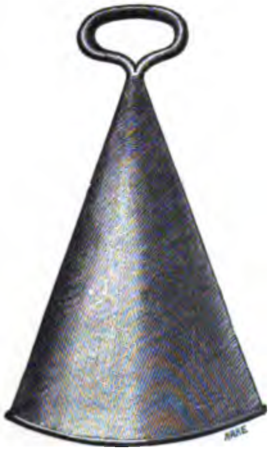

FIG. 18.—WIRE DISSIPATOR.

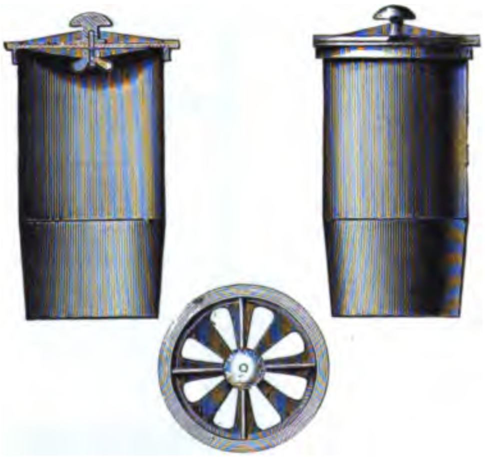

FIG. 19.—STOPES' DISPERSER.

years abroad, but none in the manner in which they are now working extensively in Britain.

In a kiln with two floors it is essential to make a sufficient number of holes to serve the double purpose of forming traps or discharge-holes when the upper floor is dropped to the lower one, and also to regulate the relative heats of the two floors by means of the dispersers or dissipators placed over each hole.

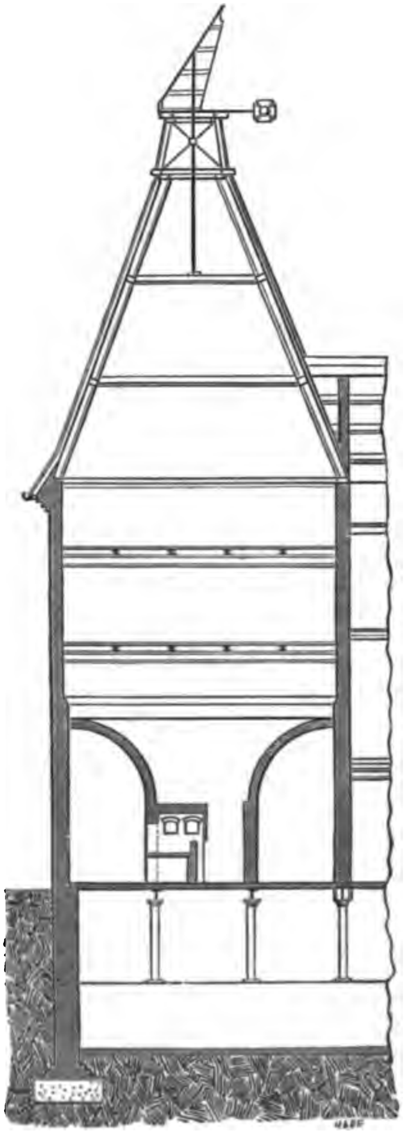

FIG. 20.—STOPES' IMPROVED KILN.

The disperser (see Fig. 19) is the best for this purpose, as it gives effective control of the ascending air, and when lifted from the discharge-hole gives the entire area of the orifice free from obstruction. Another disperser is occasionally used, see Fig. 18.

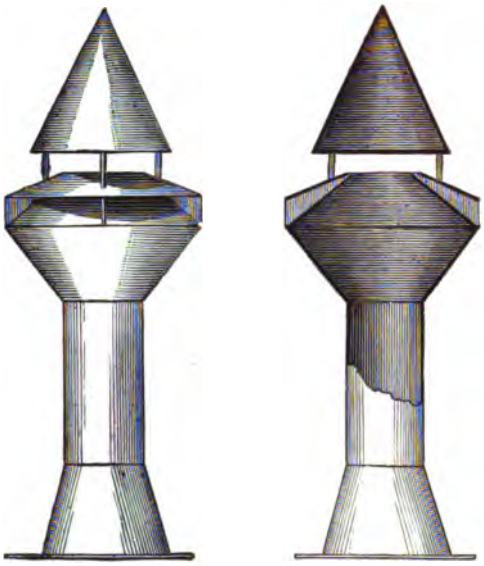

Fig. 21.—Boyle's Cowl.

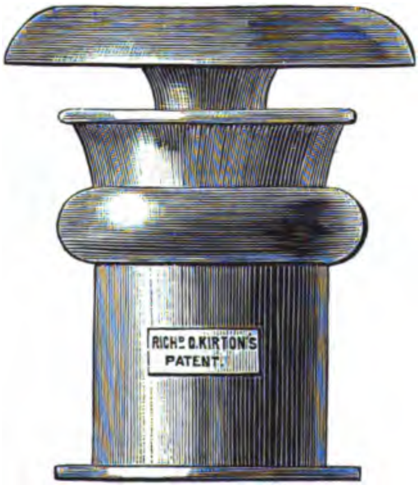

Fig. 22.—Remedy Cowl.

A kiln which gives most satisfactory results in every way can be built as shown by Fig. 20.

A Boyle (as Fig. 21) or Kirton's "remedy" cowl (as Fig. 22) can be advantageously employed in some cases instead of the common form in general use.

If it is requisite to utilise space to the utmost extent, a desirable form of construction is shown by Fig. 23.

By this plan, in a kiln say thirty feet square, it is possible to secure a hot dry malt-store capable of holding 600 to 800 quarters malt. This plan has been in satisfactory use for many years.

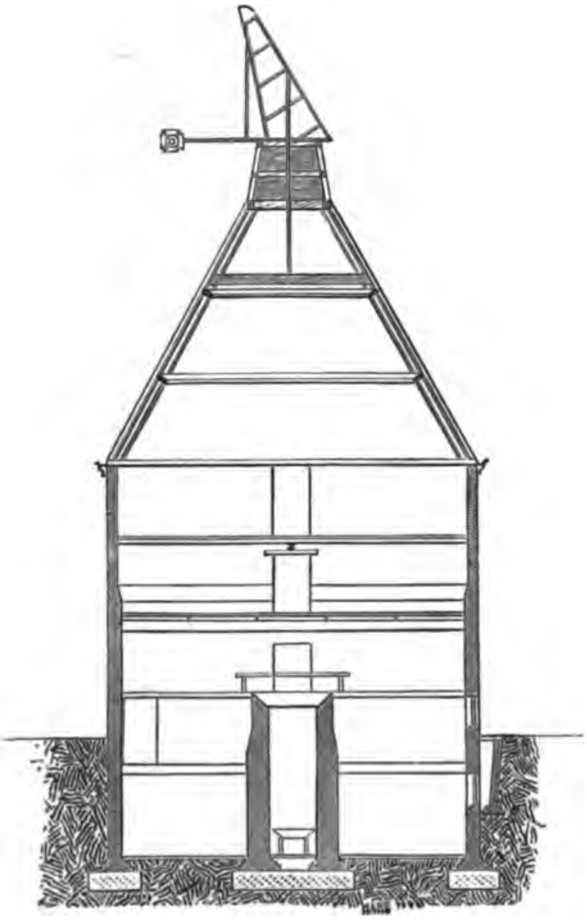

FIG. 23.—MALT KILN.

A kiln of excellent design in many respects was patented in Britain by Mr. Free. This kiln has a number of good qualities, especially in relation to height, draught, &c. So great indeed is the latter, in many cases, that the temptation to overload the floors has possibly ensued. The distribution of heat is effected in a special chamber, through which a series of brick flues is disposed, regulated by dampers, &c.

Another kiln is patented by Messrs. Tomkins, Courage, and Cracknall. The advantages claimed for this kiln are (see Fig. 1, p. 44):—

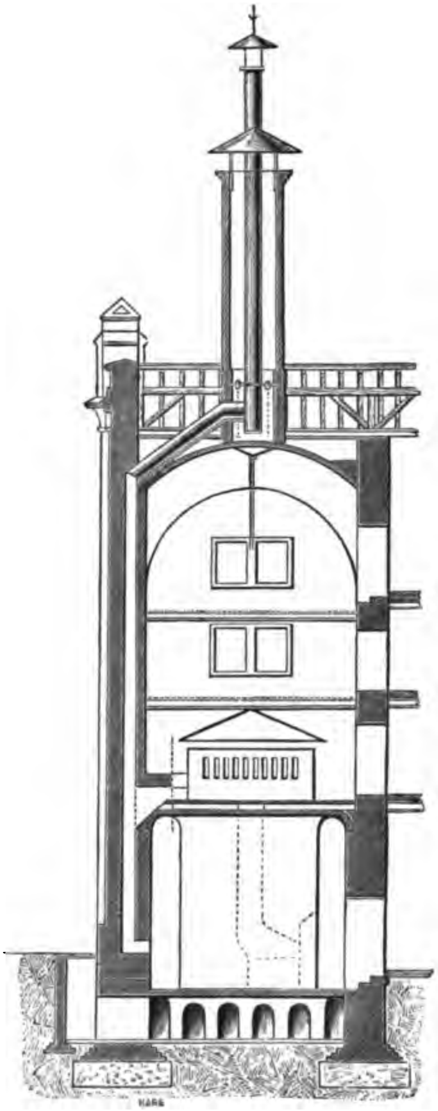

Fig. 24.—Cylinder Kiln.

" The products of combustion do not pass through the
" material being dried. [A questionable benefit for malt. H.S.]

" Malt can be dried at higher temperature than heretofore—
" say 230° to 240° Fahr., producing greater soundness in beers
" without imparting colour to ales.

"The arrangement of flues produces a very rapid draught, " carrying away moisture as quickly as thrown off.

" Coal-dust or any kind of fuel can be used, as the products " of combustion do not in any way come into contact with the " material being dried.

" There is great saving of time in drying, owing to the rapid " draught.

" Men can work on the kiln-floor at 230° to 240° Fahr., " which has hitherto been impossible, owing to their having, " under the old system, to inhale the sulphurous fumes and " work in a slow draught, which is injurious to health even at " low temperatures.

" The draught can be regulated to a nicety by opening or " shutting the dampers."

The temperature named (240°) is not greater than that obtained upon any good double-floor kiln, and the effects of drying malt with heated air, excluding the products of combustion, have not yet been successful, so far as I have ever heard.

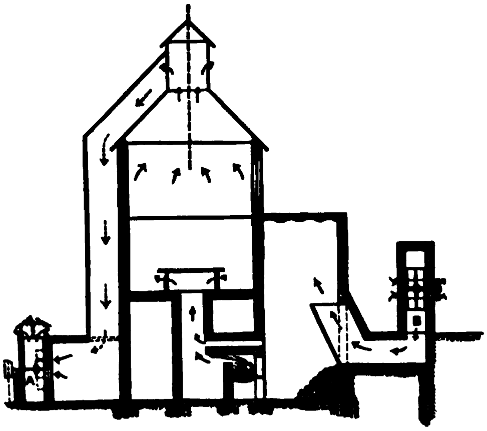

FIG. 25.—FARCOT KILN.

The kiln very largely in use abroad, known as a cylinder kiln, is of some interest (Fig. 24).

The illustration requires little explanation.*

The furnace rises as a large cylinder of cast-iron, closed at top, which does not admit of the products of combustion coming into contact with the malt, the flue being carried in a side wall up to the outlet-pipe. The inlet-pipe is of excellent construction.

Numerous efforts have been made to dry malt more speedily by driving larger volumes of air through it by the aid of fans.

The Farcot Kiln (Fig. 25) illustrates one method of accomplishing this.

M. Farcot places the furnace of the kiln in an enclosed chamber, constructed so that the supply of air can only enter through the apertures constructed for the purpose. The air is drawn from the exterior by a Farcot fan, and causes a certain amount of pressure in the heating chamber at the bottom of the kiln. Connected with the heating chamber is another fan, driven by power. In the centre is the furnace, in which coke is burned. The entrances to the chamber are fixed so that the pressure of air within it can be maintained at any required degree. The air-apertures are arranged and fitted with controlling slides; the chamber itself is made sufficiently large not to obstruct in any way the working of the kiln, or the furnace, and the management of the regulating dampers. The air collected in the heated chamber passes through passages into another chamber situated above the furnace, where it mixes with the products of combustion. As the admission of air, by aid of the ventilators, can always be kept under complete control, it is easy to regulate the temperatures with exactitude. A distributing plate placed over the passage from the furnace prevents the air from escaping directly into the central chimney, and causes it to be distributed equally under the whole of the kiln-floor. These kilns are constructed with either one or two drying-floors.

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* For fuller description of continental kilns, see THAUSING, Preparation of Malt and Fabrication of Beer.

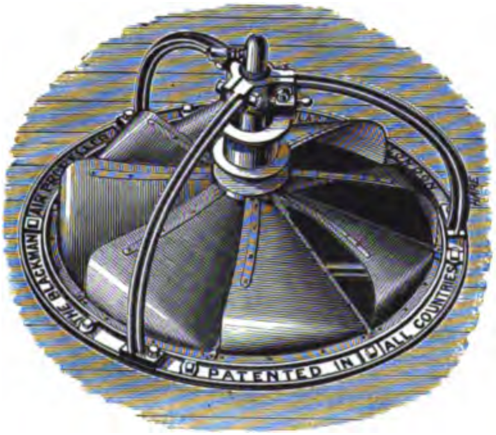

FIG. 26.—BLACKMAN AIR-PROPELLER.

The mixture of gases maintain a pressure within the whole of the kiln, greater than that of the atmosphere, and thus prevent the external air from entering at any point. As this pressure can be regulated at will, it follows that, by producing a more or less rapid current, the drying of the malt can be hastened or retarded as the circumstances of the case require. By thus employing a current of air under pressure, as large a quantity of air can be admitted into the kiln as is thought desirable, for there is no difficulty in the matter of obtaining a draught, which is sometimes the case in ordinary kilns. The kiln is enclosed by a dome, and provided with a shaft, through which a downward current is established by the aid of another suction-fan. In some cases it is found preferable to arrange chimneys at the four corners of the kiln, the openings to which are immediately above the upper floor. It is claimed that any existing kiln can, without much difficulty, be altered and fitted with the Farcot system of ventilation.

The same effect is produced more easily and simply, and with the employment of much less power, by the Blackman Air-Propeller (Fig. 26).

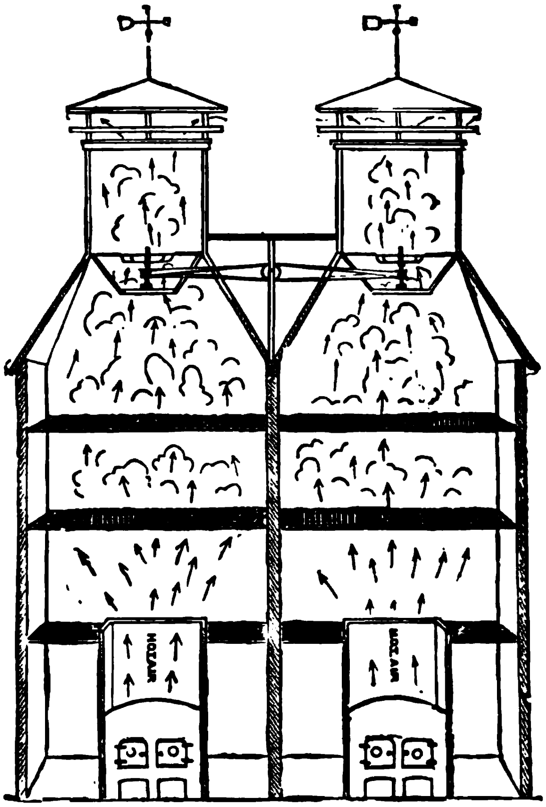

Fig. 27.—Kiln with Blackman Fan applied.

The application of this fan to kilns is shown by Fig. 27.

This mode of drying malt is in use in America.

The fans used in malt-kilns are generally placed at the base of, or within, the cupola or air-shaft, and made to revolve horizontally. Owing to the position of the blades, their revolutions exert a strong lifting force, drawing the air up and out of the air shaft, thus producing a partial vacuum. The natural pressure of the air entering cold air-boxes tends to force it up through the malt to fill this vacuum. The advantages claimed for this method of drying are:—

1st. The fan assists the natural upward tendency of heated air.

2nd. It causes a uniform draught, perfectly independent of atmospheric conditions.

3rd. It allows the use of less heat, making paler and softer malt.

4th. It effects a saving of fuel and time.

The too rapid drying of malt is undesirable, and numerous methods of drying, that have been suggested and tried, have failed to yield satisfactory results.

One of the most rapid plans was that patented in 1880 by Reynolds.

"It is claimed for this kiln that the construction is very simple, giving perfect facility of management, and that, without interfering with other arrangements, it may readily be adapted to present maltings, or be erected in any ordinary building. Skilled labour is dispensed with, weather or climate exercises no influence on its operations, while a plumper and more evenly-dried malt is produced in a *few hours* than has hitherto been accomplished in days. The moisture in the grain is gradually but effectually extracted, while there is no possibility of the malt getting kiln-dried or burnt, notwithstanding that it is cured at this extraordinary rapid rate, and in a temperature hitherto unapproached for the purpose. The whole process, from first to last, is under the most perfect and easy control, while the malt is open to inspection throughout the operation, one-half of each tray being always exposed to the cool air. There is no uneven drying, and in less than *ten hours* a malt is obtained perfectly and uniformly cured, each individual corn having received the same regular heat throughout the operation. The following experiment shows its working:—At half-past ten in the morning the malt was duly placed in the trays, and the operation commenced, when the temperature was taken, and, gradually increasing, was timed as follows:—11.15 a.m., 130°; 11,45 a.m., 135°; 12.15 p.m., 140°; 1 p.m., 144°; 2 p.m., 152°; 2.30 p.m., 160°; 2.45 p.m., 164°; 3.15 p.m., 168°. This last heat was maintained until 4.30 p.m., by which time the malt had become dry, crisp, and sweet to the palate, in addition to which the rootlets had all dropped off, and the malt presented an excellent sample of finished grain, the result of *only six hours' drying*. On analysing a sample of this malt it was found to retain only 6.86 per cent. of moisture after that brief curing, while subsequent tests as to its soundness justify the belief that there is no more probability of its ultimately going slack than in the case of kiln-dried malt. The saving it effects in fuel alone is quite 40 per cent., and the cost of labour is, comparatively, reduced to a bagatelle."

Numerous kilns have been tried containing four or more drying-floors. This was suggested in Britain by P. Stead, who patented a kiln possessing a series of drying-floors, Sept. 22, 1842, No. 9475. This same patent also covered the use of fans or other blowing engines, not only in kilns, but on double growing-floors also.

An American kiln, the Wheelwright kiln, Fig. 28, will sufficiently illustrate this type. It is claimed for this kiln that it is automatic, and does away with the labour in turning malt on the kiln. More than half the fuel is saved. It will dry malt in less than twenty hours without making it flinty or dark. The malt will be more uniformly and evenly dried. It will clean malt, taking out all the dust and rootlets while drying, or if desired they may be left in. The kiln may be located either inside or outside of the malt-house. It is more compact, requiring only about one-fourth as much room as the old style of kilns.

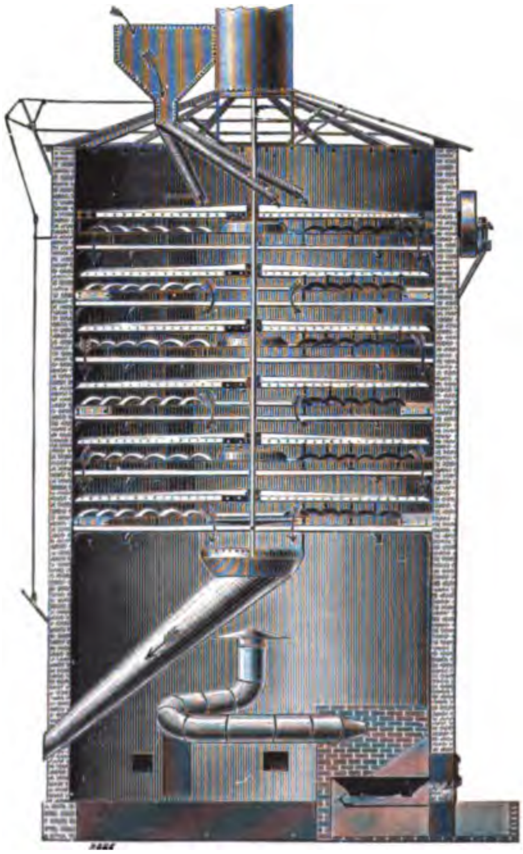

Fig. 28.—Wheelwright Kiln.

Very numerous designs for kilns with any number of floors have been made, but they all labour under the fatal objection that the relative heats upon the various floors cannot be rightly regulated.

The Gecmen kiln (Fig. 29) is in use in many places on the Continent and in America.

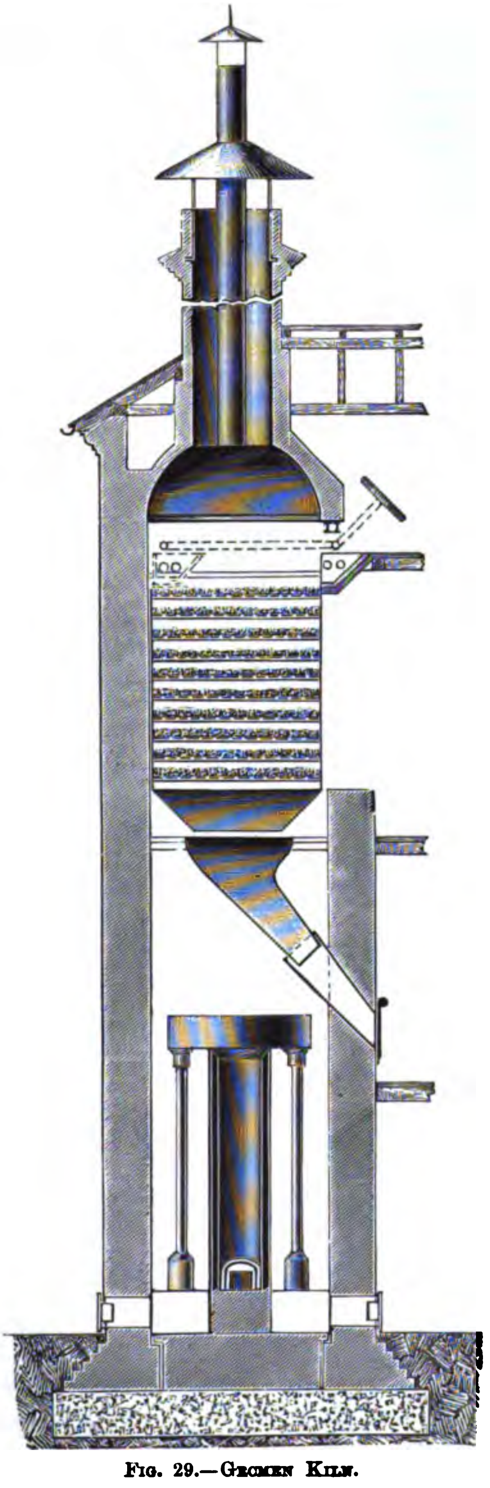

FIG. 29.—GROMEN KILN.

The number of floors employed ranges from four to twenty. They consist of a series of gutters of small size, made of perforated sheet iron, and so fixed that they can be made to tilt over easily. They are generally attached to each other so that by moving a lever a whole piece can be thrown down upon the floor immediately below it.

As the whole time of drying upon these kilns is from eight to twelve hours, it follows that the malt rests for very short periods upon each floor, and turning is very frequent.

The bottom floor drops upon a self-emptying hopper, so that the labour for working a kiln upon this plan is very small.

This kiln dries forty-five quarters of malt, per ton of coal burned.

Numerous other kilns, embracing the same principles of drying, have been invented, but it remains yet to be proved that they possess any distinct advantage over the ordinary open-fire kiln.

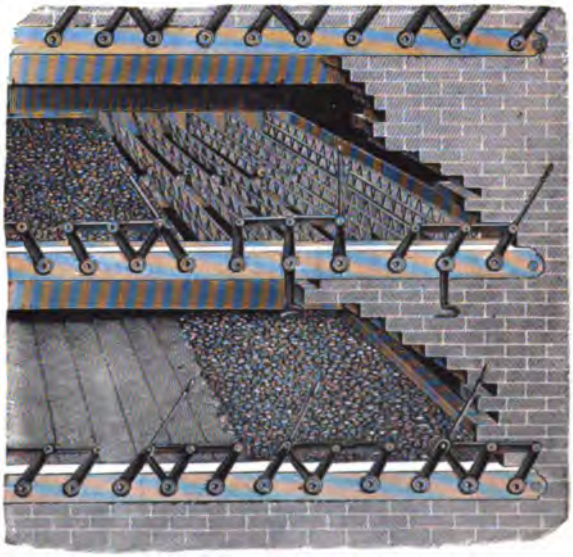

FIG. 30.—TOEPFER'S DUMPING KILN.

In a very large malt-house in America belonging to Ph. Best Brewing Company, Milwaukee, the kilns have Toepfer's dumping-floors. Each kiln has four floors, which are discharged in the manner shown by Fig. 30. The time taken to discharge 600 bushels of malt from one floor to another by this arrangement is five minutes.

Another form of kiln has been invented and patented by Seagrave and Bevington.

This kiln is practically an air-heater. It can be arranged to incorporate the products of combustion or supply pure hot air at will.

An endless-band kiln has been invented and patented by Messrs. Gillman and Spencer. It is used by them to dry gelatinised corn, and answers its purpose admirably.

In the construction of kilns, the mode of loading the green malt and discharging it when finished, is of some importance.

In the vast majority of malt-houses, especially of small size, the height of the floor above the furnace is inconsiderable, and it has been the custom to load or throw in the malt with a shovel. When the height is increased, and another floor is also added to the kiln, it is rarely possible to continue this practice, and the green malt has to be hauled up in baskets by some simple form of windlass, or some other plan has to be adopted.

The use of ordinary grain-elevators for green malt is objectionable, for several reasons. Dragging in on sacks is bad. Throwing in by shovels is often impracticable. Carrying in baskets should be avoided unless the baskets used are small.

The best plan yet devised is an endless belt of indiarubber, which should be adopted in all cases where practicable.

For discharging dry malt an endless worm-conveyor or a chain-elevator can be employed, depending necessarily to some extent upon the relative levels of floors in kiln and store.

Roof.

The construction of the roof is of great importance, as very much depends upon it. If the shape is not good, the drying of the malt is affected. If it is not massive and strong, it occasions trouble. If it is thin, it condenses the steam within. If it is badly plastered or boarded, it is a frequent source of expense.

Cross-timbers are objectionable, and can in most cases be avoided.

Light rafters should not be used, and in no case should they be left naked.

Lath and plaster is the best inner skin, and, where convenient, the purlins also are best plastered. The tops of the rafters should have good, well-seasoned inch-and-quarter boarding securely nailed to them.

If this boarding is ploughed and tongued, the expense is amply repaid in after use. Upon this, good felt should be fastened. Then the slates should be nailed, with extra stout and double copper nails, *not* to the boards, but to ordinary slate battens nailed above the felt. This gives a roof about which no complaint can be raised excepting first cost.

Slates, then an air-space, felt, close boards, and a second air-space, with good plaster free from every obstruction below, make a roof far cheaper at the end of seven years' use than the trashiest roof ever designed. A question of great practical difficulty to determine, is the right lining for the inner face of roof. Match- or other lining decays speedily, and all exposed surfaces of timber are also rapidly affected by the heat and vapour. Hair-mortar, cement, or any other plaster speedily loses its key and drops off. The only exception to this is the plaster made with Blue-Lias lime, burnt in the Easton Pits, Stamford.* This is worth the extra cost, as it stands for many years, when once properly applied. It has been used for a long time by many of the best maltsters of the Midland counties and elsewhere. This lime, well made, with an extra allowance of cowhair, makes the nicest and best surface for kiln use, and is the most durable roof I have yet seen.

Drying-Floors.

All malt kilns should possess two drying-floors. These are commonly made of a diversity of materials and fixed in numberless ways. Thus there are earthen tiles of several makes, cast iron tiles, perforated sheet iron, woven and twisted wire, and woven horsehair. The Herrmann wire forms a singularly strong and level floor, which permits of the greatest area possible for the free passage of ascending heated air. It is very durable, and incapable of getting out of repair, and never damages the most tender or friable malt by inequalities of surface. The chief objection to woven wire is its comparative frailty. It is very largely used, and is much liked by some. Earthen tiles are liked by many eminent maltsters and others, chiefly because they are supposed to be capable of regulating the temperature of the air, which follows the intensity or dulness of the fire. The tiles naturally absorb or give out heat relatively to these changes. One objection to their use is the small free area of holes, and the wide margins entirely blocking the passage of air. In nearly all cases they are roughly fixed, so that when shovelling green malt upon them, many kernels are broken or damaged. Of iron tiles still more may be said, as they possess nearly all the defects already set forth, without one of the supposed advantages. Their sole merit is that they do not break readily.

The Herrmann patent wire is made in two forms. The round section, Fig. 31, was first used, and was for some years much esteemed.

A new invention of wedge section is much better than the round. This wire, Fig. 32, possesses the very distinct advantages of a flat top-surface, greater area for the passage of air, together with a larger amount of wire per square foot, disposed in the position of greater strength.

The chief disadvantages of this floor are its apparently large cost and the difficulty of getting it, in consequence of the large demand. The true relative cost is, however, to be estimated by the value of the material supplied plus its effective use. Judged by these considerations, the Herrmann floor is best and cheapest.

A square foot of wedge-section Herrmann wire weighs 7¼ lbs., which is, compared to perforated plates or woven wire, relatively very much greater. This wire is, however, composed of Bessemer steel of fine temper to stand the pressure of the hydraulic presses in a cold state, which give it its form. The air space exceeds thirty-seven per cent. of the total area. The wire is made in strips of varying width, generally from thirty to thirty-six inches, and of the length or breadth of the kiln to which a floor is to be added. Single strips upwards of fifty feet long are ponderous to handle, and require care and experience to fix them easily and well.

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* Worked by Messrs. Burrows and Higgs.

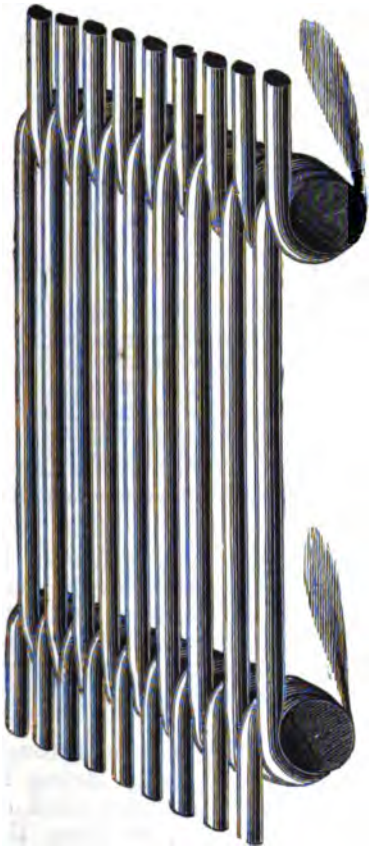

Fig. 31.—Herrmann's Round Section Wire Floor.

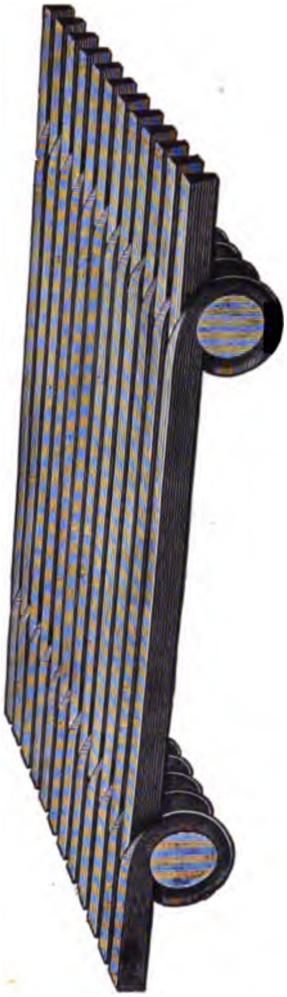

Fig. 32.—Herrmann's Flat Section Wire Floor.

This wire is always supported upon thin bars on edge of a section of $1\frac{1}{8}'' \times \frac{3}{16}''$ to $2'' \times \frac{5}{16}''$, which are stayed and bolted together at suitable intervals and inserted into the walls at each end. These in turn rest upon main carrying joists or beams properly fastened to the opposite walls.

A form of floor similar in some respects is in use in America. It is called the "Perfection" malt kiln floor, patented by Mr. F. W. Wolf. This also makes a splendidly strong and level surface upon which to dry malt.

Punctured or perforated sheet-iron was formerly used to a considerable extent in kilns for drying floors. Unless perforated as fully as Madocks' patent it has little to recommend its use. This form of floor is, however, capable of beneficial use, and it is claimed by Mr. Madocks that it is very durable, and has a sufficiency of air-space for all practical purposes.

In these plates there are generally 729 holes per square foot, each an eighth of an inch in diameter. This accordingly gives five per cent. effective air space and ninety-five per cent. heating surface.

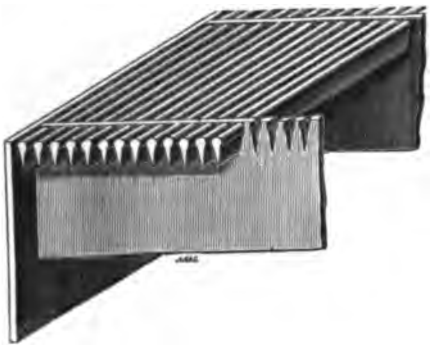

Fig. 33.—Wolf's Wire Floor.

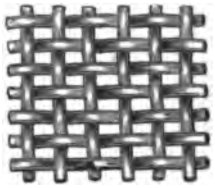

Fig. 34.—Woven-wire Floor.

Woven wire has been very extensively adopted for floors. It is comparatively cheap, and if properly cared for is very durable. It is ordinary round or square wire of from twelve to sixteen B.W.G., woven in a loom. (See Fig. 34.) It is made in rolls of varying width, and of any required length. It is attached to the walls of the kiln in several ways, of which the simplest is shown by Fig. 35.

The wire is commonly drawn tight by bolts passing through the walls of the kiln, and is generally sufficiently strong to carry the weight when loaded, especially in medium sized or small kilns. It is never desirable, however, to leave the bearers out; these are commonly small round rods of from half-inch to one inch in diameter, which in turn rest upon stiff cross-plates or girders. Very frequently cast-iron grids or gratings are employed as bearers to wire-floors, and these are variously supported. As in time even the best floors drag down to the bearers, the use of cast grids is fraught with danger to the wire, chafing upon the sharp rough corners. Consequently they are improper for such a purpose.

The best form of woven wire is made in America and Germany. It is there called rolled wire-cloth, and has a much better and smoother surface than English woven wire. The construction and merits of this cloth are shown by Figs. 36 and 37.

The join in this cloth is effected in a very neat and simple manner. (See Fig. 37.) Woven wire is commonly laced together with fine binding-wire.

Wire floors of all kinds, if well and properly laid, are very durable when duly cared for. They last very many years. Their distinctive advantages are the very great air-surface they afford, and their smoothness. Stout woven wire offers fifty per cent. of air-space to fifty per cent. of metal. It contains about thirty-five holes per square inch. Thin woven wire contains as many as fifty holes. Such wire is naturally more quickly destroyed by damp than the stouter kinds. No real benefit is derived from the use of too many holes, provided they are equally distributed.

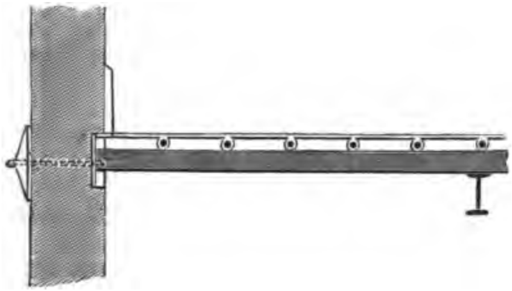

Fig. 35.—Mode of Fixing Wire Floor.

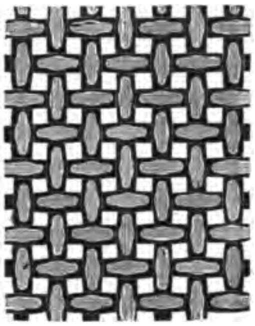

Fig. 36.—Rolled Wire Cloth.

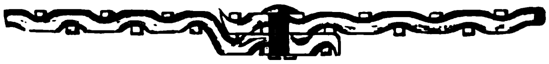

Fig. 37.—Section of Rolled Wire Cloth.

Tiles.

Many malt-kilns are fitted with tiles. These are perforated earthenware or cast-iron. The manufacture of earthen kiln tiles has been brought to great perfection; they are both glazed and unglazed; generally about twelve inches square, and nearly two inches thick. The greatest amount of air space with maximum strength is attained by making round or hexagonal holes of considerable size nearly through the tile, and then pricking in a bunch or cluster of small holes in the crown of each hole or cell. (See Figs. 38 and 39.)

Earthen tiles are usually rather brittle, and consequently get broken. To prevent this they have been made of cast-iron for upwards of a century. The merit of tiles is their retention of heat. This cannot apply to cast-tiles, which, however, excel in strength.

Cast-iron Tiles.

These are still employed, and are approved by numerous users. Curiously, they were patented November 14th, 1783, by one Richard Clarke (No. 1395). They are thus described:

> " The present invented plates being made of cast metal iron, " require less fire and retain the heat longer than those made " of tile or hot clay. They may be made square, or oblong, or " any other shape by which they may join and be close to each " other, and of such size and dimensions as the purchaser may " think proper. These plates have a greater or less number of " holes countersunk smaller upon the surface of the plate than " on the other side, for the purpose of admitting a greater " quantity of heat to the malt."

When tiles are used they require to be laid with great care. Under the best circumstances they present wide margins upon which green malt can lie and stew without any air having direct access to it. If the tiles are uneven, such malt rarely gets shifted, and consequently it is simply dried by baking.

Irregular surfaces are also extremely bad for green malt if it is shovelled or ploughed upon them.

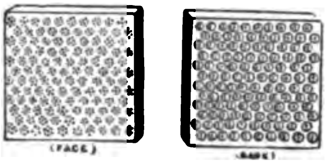

FIG. 38.—STANLEY KILN TILES.

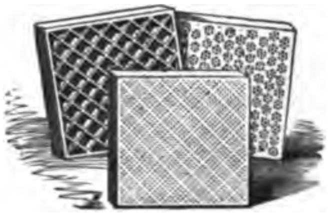

FIG. 39.—FISON TILE.

It occasionally happens that the rough surface of the under edges of the major holes catch and retain the rootlets and dust as they drop through. I have some tiles in my possession which have every hole blocked completely by this means. How the combes managed to get into this position is a mystery not fully explained by assuming that spiders did it.

The supporting floor for tiles is usually a series of light bar irons on edge resting upon larger joists. The sizes of these are ruled entirely by the dimensions of the kiln.

The actual air space of a tile is irregularly distributed, and does not amount to 20 per cent. of the total surface. The number of holes sometimes equals nine or ten to the square inch, but every tile possesses a solid margin of considerable area entirely free from holes.

No tile is made which does not offer considerable obstruction to an ascending current of air. Under no circumstances should the thin and imperfect tiles formerly made be re-used in a new kiln.

Tiles may offer some advantages over wire for a barley kiln, but these are not yet proved, and are scarcely worthy of serious consideration. I, however, find their use in the bottom floor of a kiln serviceable.

Horsehair.

This material is so seldom used now that it requires but slight mention. It is still to be found in some kilns, and is supposed to preserve the colour of the malt—a virtue which (like many others) exists only in ignorant assumption. It is stiff horsehair woven with a coarse mesh. It is secured in the kilns to boards fastened to the walls, and rests upon splines of wood placed somewhat closely together, resting upon main carriers or bearers. This type of floor promises to become as rare as the use of perforated boards for the same purpose.

Baffle-Plates.

The majority of the kilns in Britain have a plate between the drying floor and the furnace. This has various names—such as spark-plate, fly-plate, baffle-plate, shield, reflector, apron, sparkstone, guard, &c., many of which indicate its use and purpose. If a kiln has a properly-constructed roof with right outlets, the floors at proper levels, and a well-constructed fireplace, these plates are not only useless, but a positive harm to the drying malt.

They are commonly of sheet-iron, and occupy about one-half to one-third of the area of a kiln-floor. They are placed at all levels between the fire and drying-floor. Sometimes they are left flat; often they are fixed with one end higher than the other. They are fitted both with and without dewlaps, side-flaps, or vertical hanging pieces.

As their use is a delusion, it is needless to describe them more fully.

Furnaces.

One of the most important points to consider in erecting a kiln is the fireplace. If the whole kiln is regarded simply as a large furnace with a big throat, it simplifies matters very materially. Practically this is all it is. Study the relative dimensions of the inlets and outlets and their best positions rightly to secure the desired result, and designing a kiln is easy. The only problem which varies from the basis upon which a furnace-builder works, is the uniform distribution of the heat at a point, or points, presenting the largest available area within the building. As in practice it is found that the intervention of a double layer of malt causes almost perfectly uniform distribution of air, no real difficulty arises from this additional requirement of a kiln.

In everything connected with malting, great diversities of size and style occur. Furnaces do not offer any exception to this rule. Almost every conceivable type and form are still in use, or have at some time been used. These furnaces either permit the products of combustion to pass through the malt or they do not do so.

No other distinct line of demarcation can be drawn around maltsters' furnaces. They are made of all heights and sizes, utterly irrespective of any law, assumed or proven. With the majority of kiln-builders such a thing as real consideration of the subject is unknown.

The principle of chimney draughts has been already explained (p. 196.) For all ordinary open-fire kilns, the practical and economical application of that principle suffices. But there are numerous other types of kilns constructed. Consequently we find that kilns can be divided into two distinct classes.

1. Fire-kilns.
2. Air-kilns.

And that these classes in turn can be subdivided into

1. Fire-kilns—
    - Brick furnaces, open.
    - Do. in shafts.
    - Fire-baskets.
2. Air-kilns—
    - Air heated by open combustion of fuel.
    - Air heated by steam.

I cannot at this point discuss the relative merits of air- or fire-kilns beyond marking the distinction, and drawing attention to the fact that if malt can be produced in air-kilns as satisfactorily as in open fire-kilns, the latter are doomed, and must disappear, for the advantages of air-kilns are numerous and decisive.

FIRE-KILNS.

Open Brick Furnaces.

These are generally built with fire-bricks or lumps at the sides, set in fire-clay, and with a semi-circular arch, also turned in fire-brick. The common width ranges from one foot six inches to two feet nine inches, and length from three feet six inches to seven feet. So far as I have yet seen, the size is rarely regulated by any standard. It appears commonly a matter of opinion on the part of the builder. The grate is usually heavy furnace fire-bars carried on bearers.

Very generally the whole of the air for the drying-floors passes through the grate opening. Side ventilating holes are frequently found, and these give the maltster a greater command of his work upon the floor. These holes are variously fitted. Some have sliding doors, and others pivot-hung valves of light sheet-iron.

The area of grate varies largely. It must necessarily be ruled, to some extent, by the height of kiln to outlet. A lofty kiln can have as much as 120 feet of floor to one foot of grate.

The erection of furnaces of this sort requires care, and materials equal in quality to Stourbridge should be used; otherwise frequent rebuilding is necessitated.

Shaft Furnaces.

Kilns in which a height exceeding fourteen feet is allowed between fire-bars and drying-floor, are constructed frequently with a square shaft, rising through a malt- or store-room.

These shafts are of brick, and are commonly lined with fire-brick. Side ventilating channels are left in the walls, which have regulating doors or dampers affixed to them. The furnace has also, as a rule, a tight-fitting double door, so that both furnace and ashpit can be closed.

When these shafts are used, it is usual to have an air-distributing chamber immediately over the store and below the drying-floor. This chamber is comparatively low, having a height of from four feet six inches to seven feet, and the air is distributed within it by a plain baffle-plate, or by an arrangement, patented by Mr. Free, of radiating arms or flues connected with a central dome, and fitted with a series of regulating dampers.

Fire Baskets.

Many kilns are fitted with large open cast-iron baskets of from three feet to six feet square. These have legs or supports carrying a frame fitted with ordinary fire-bars and thick sloping sides.

These baskets are sometimes placed merely upon the bottom floor of the kiln, and have no protecting sides or spark-plate.

Others are built over with a brick arch left full of holes for the escape of heat on all sides. Others have a small enclosure fitted with four doors and a spark-plate.

None of these plans admit of right control of temperature or of inflowing currents of air. Although these baskets are much liked at Burton, Newark, and other important malting centres, their use cannot be recommended, or, as a matter of fact, sanctioned.

AIR-KILNS HEATED BY FIRE.

In other countries kilns of this class are almost universally used. The creosoting influences derivable from direct contact of the corn with the fumes from the fire are ignored. It yet remains to be seen if malt dried in this manner can be used with satisfaction by English brewers. Should it be so, this type of kiln is very desirable.

Almost any form of furnace or stove can be used for kilns of this order, as it is simply requisite to get a large volume of air heated to any required temperature not exceeding 250° Fahr.

The flues are commonly made with sheet-iron, and of considerable diameter and length to furnish a large area of heating surface. Provision is also made for the admixture of cold air to prevent over-heating.

Steam-Kilns.

These are seldom used, and require little description. The air required for drying the malt is heated by passing through a series of steam-pipes in which super-heated steam circulates. No real reason for this method of heating exists.

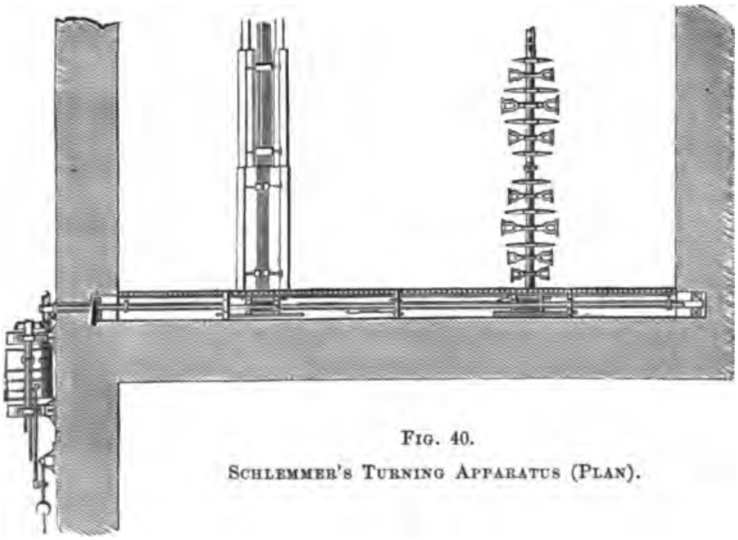

Fig. 40.
Schlemmer's Turning Apparatus (Plan).

Mechanical Turners.

Many continental kilns have an arrangement for regularly turning the drying grain. These are often automatic in action, and work with great perfection. They are used as frequently as every thirty minutes in some cases.

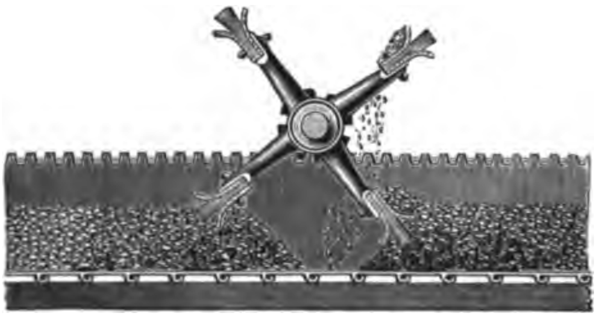

Fig. 41.—Schlemmer's Turning Apparatus (Section).

The automatic turner chiefly used is patented by Schlemmer (Figs. 40, 41). This machine is either driven from shafting by three pullies or has a separate engine for its own working. It consists of a shaft traversing the whole width of the kiln, and fitted at both ends with cog wheels. These run in racks attached to the side walls. Upon the shaft, series of blades or turners are attached, which when in motion gently raise the malt and deposit it on the other side. A lever arm reverses the motion of the driving belt directly the shaft reaches either end of the kiln, and the turner proceeds in the opposite direction. The movement is a very slow one of about one foot per minute. An ingenious arrangement of shifting plates prevents any malt getting lost or damaged by the cogs.

Another mechanical turner has been invented and perfected by Mr. A. Perry, Rathdowney.

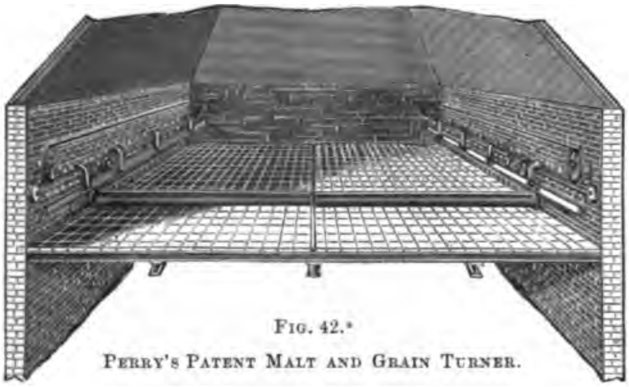

Fig. 42.*

Perry's Patent Malt and Grain Turner.

This machine has been designed to save a large proportion of the labour now used in turning the malt on the kiln and also upon the growing-floor of the house. It completely and thoroughly moves every grain, and consequently ensures a more even temperature and uniform quality of production. By the ease with which the bed is turned, every grain of malt gets its proportionate share of heated air. By a more complete separation of the grain, the bed is laid lighter and more open, thus rendering the passage of air more complete and thorough. The time taken to turn a kiln holding eighty quarters on a floor thirty-six feet square, is about ten minutes. It is claimed for these machines that a considerable saving of labour and fuel is effected by their use.

Malt-Stores.

The majority of malt-houses are constructed to store or keep as well as to manufacture malt. Some maltings of large size, or exceptionally placed, have independent buildings in which to store the malt or barley.

Each malt-house is more conveniently worked if it has storage room for three to four months' consumption of barley and six months' output of malt.

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* Perspective drawing prepared by Mr. G. R. Wilson, Frome.

These stores to a certain extent can be interchangeable, as barley-stores at the end of the season can store malt, and *vice versâ*.

In constructing stores the three considerations are—

1. Exclusion of air.
2. ,, damp.
3. ,, weevil.

It frequently happens that stores are designed imperfectly, and incapable of sustaining the weight put upon them. As all stores are occasionally filled to their utmost capacity, it is safer to calculate the weight they must sustain as the gross weight of their total capacity filled with dry maize, or 50 lbs. for every cubic foot.

In constructing bins for grain, some engineers prefer to regard the corn as a fluid, and to calculate weights and pressures upon the assumption that it is not an inert mass.

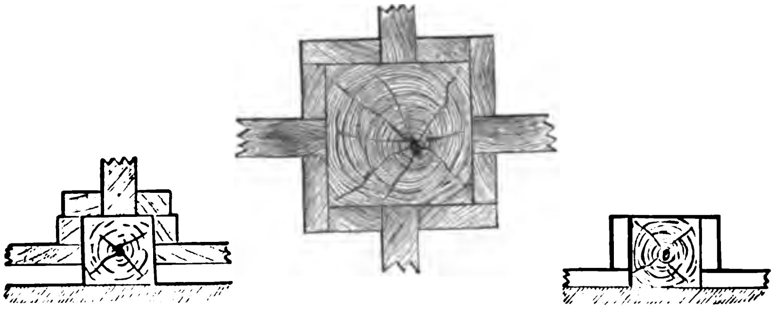


FIG. 43.—STOPES' BINS.

With shallow bins, weight alone requires consideration, but in deep bins the lateral pressure has to be carefully calculated. Hydraulic rules may be of great use in these calculations, for in the absence of experience in bin-construction, the assumption of fluidity of the material stored induces the builder to sufficiently stay the walls or partitions, and to make them strong enough to prevent accident and loss.

Very frequently it happens that floors break through or walls are pushed over, because the designers do not fully appreciate the nature of the thrusts to be resisted.

Weight of corn does not rest on bottom entirely, but is supported by the sides as well. In a deep bin, so soon as the depth exceeds the diameter, very little addition is made to the actual weight or pressure upon the bottom. The additional corn is supported by friction against the sides of the bin and of the grains against each other. It is also important to note whether vibration occurs in the malting, as it seriously affects this question.

The curious facts connected with the pressure of grain in bins, carefully experimented upon by Mr. Roberts and given to the world by his paper read at the Southampton meeting of the British Association, 1882, require to be carefully studied in building such large malt-stores as must necessarily be attached to maltings of large size.

In small maltings the upper or middle floor is generally used as both malt- and barley-stores.

In larger maltings the top floor is more generally so used.

Customarily the bins are fixed. Weevil are accordingly greatly favoured. No bin need ever be permanently fixed. It is usually convenient to have right-ups or posts every six to eight feet; if these are constructed according to diagram, Fig. 43, it enables every part of the stores to be removed for the purposes of cleaning, &c.

Each bin for barley is usually more convenient if it holds from twenty to sixty quarters. Larger bins are dangerous unless the corn is very dry.

Accordingly malt-stores should have massive, damp-proof walls, double floors, and removable partitions throughout.

Kilns of large size can generally be arranged to admit of a portion of their space between fire and floors to be devoted to storage purposes.

The arrangement of belts, conveyors, elevators, screens, &c., will be found under "Tools and Apparatus," Chaps. XVI. and XVII.

CHAPTER XIV.

PNEUMATIC MALTINGS.

"We shall find that the values of things depend upon the total quantity of labour necessary to manufacture them, and bring them to market . . . . Economy in the use of labour never fails to reduce the relative value of a commodity, whether the saving be in the labour necessary to the manufacture of the commodity itself, or in that necessary to the formation of the capital, by the aid of which it is produced."—Ricardo, Principles of Political Economy and Taxation.

Pneumatic Maltings:—
Galland's Malt-house. Saladin System of Turning. Saladin's Malt-houses at Troyes. Diagram of Temperatures—Stopes' System. Rotatory System. Table of Costs. Practical Working of Saladin House.

All maltings worked in the common manner, together with those worked upon the Continental and Stopes' systems, labour under the disadvantage of inability to control rightly the temperature and conditions of air-supply to the germinating grain.

A comparatively new form of malting is known as the "pneumatic system," which may be freely described as the absolute control of the conditions of all air supplied to growing grain, and its consequent modifications of growth.

This system has been known for several years, and is largely adopted abroad. Owing to our singular insular prejudices, only five of these houses are as yet at work in Great Britain, notwithstanding that the first pneumatic malting successfully worked was at Messrs. Perry and Co., Roscrea, Ireland, and that the principle was patented by Stead in 1842. All users are well pleased with them, for they possess numerous advantages, with only one disadvantage (if it may be called one in this mechanical age), viz., the consumption of greater power, and a consequent reduction in the number of workmen to one-third of that otherwise necessary. The area occupied by the buildings does not equal one-third of ordinary houses. The actual growing-floor space is only one-seventh, whilst the use of plant and premises is continuous, the process of malting being equally well conducted in the hottest weather.

From this it will be seen how very widely this system of malting differs from that we have been chiefly considering.

No very material difference in the construction of the buildings is required from a structural point of view, exclusive of area of floors. In the ordinary pneumatic system, the kilns remain the same. Malt-stores are smaller, barley-stores larger, growing-floors much smaller, differently placed, and very differently constructed.

It would be difficult and tedious to follow all the inventions relating to pneumatic malting, made or suggested by Tizard, Graham, Perry, Galland, Marbeau, Gecmen, Jacobsen, Saladin, and numerous others.

One of the earliest practical attempts to malt with deep layers, made by Galland, speedily proved the importance of proper turning and ventilating the grain. This was taken up by one of his assistants, M. Saladin, and worked out to a practical issue.

During the first few years after pneumatic malting had been applied to ventilate thick layers of grain, it was generally believed that a means was found of henceforth dispensing with the manual labour of shovelling and with the enormous cellars and growing-floors which are necessary for the operation, such as are still in general use.

The question, however, was not completely solved. The ventilation which allows malting in thick layers, and saves merely a great deal of space, has always proved a failure whenever the inventor neglected to turn the entire mass of grain, and no fair quality of malt could be produced except by adding manual stirring to mechanical ventilation.

The invention of mere ventilation became, therefore, useless, since it produced but little economy, or any other marked advantage. Henceforth it became a matter of absolute necessity to have again recourse to hand-labour in order to stir the grain.

Now manual stirring is an imperfect proceeding, a sort of half measure, as bad as the others. This can be testified by all those who, having erected receivers with thick layers, stir the latter only with the shovel. They nearly all feel the defectiveness of this process, and how desirable it is that this indispensable operation should be performed in a complete, perfect, and sure manner. The work has been aptly described by M. Saladin, who says:—"I have seen many pneumatic "maltings with manual stirring. All was going on well under "the master's eye, though the workman had a much harder "task to turn over with his shovel the deep layers of corn than "the thin layer on a common germinating-floor. But that was "his own concern. The master, unable to be constantly "present at the stirring from beginning to end, kept a watchful "eye for some weeks, and then trusted his workmen. What "was the consequence in most cases? The workman also "relaxed his zeal, did his work in a slovenly manner, and a "notable quantity of the corn remained unmoved at the

" bottom; the stirring was incomplete, and the maltster " perceived it only when it was too late to remedy the evil."

The grains which remain too long in contact with the floor become more impregnated with moisture and heat, and begin to shoot much sooner than the others. Their radicles become entangled, pass through the holes in the floor, stick in them, and can be detached only with a good deal of trouble. Not only the apertures in the false bottom become choked, but the ventilation of the great mass is checked, the unstirred grains shoot out the plumules, and thus exhaust their provision of useful substances. If, after that, the workman picks out these grains, and mixes them with the others in order to conceal his carelessness, the malt will be of an uneven and inferior quality.

Nay, the consequences are even worse than that. Every practical maltster knows perfectly well that the layer of grain in germination begins occasionally to sweat, because the vapour which disengages itself from the heated grains of the lower range, becomes condensed on the grains at the surface exposed to a lower temperature. This effect manifests itself especially in thick layers, with an intensity proportional to the mass at work. Now, if the layer remains unmoved, the moister grain at the surface can only vegetate in a condition very different from that of the hotter and drier grain of the lower range, and produces in the end a malt of very uneven quality, and this can only be remedied by a judicious stirring at the proper moment, in order to mix the entire mass thoroughly.

The main object, therefore, is to adapt to the ventilation of thick layers a system of mechanical stirring, which might enable the maltster or his foreman to stir those layers as often as he thinks fit, and that this stirring should be accomplished in a thorough, perfect, and reliable manner.

This is precisely the point which has only recently drawn the attention of inventors of pneumatic malting, and M. Saladin was the first to invent an apparatus answering this requirement.

The question of perfect stirring being a necessary and indispensable action in pneumatic malting, ensures not only the requisite quantum of work well done, but brings also with it what cannot be obtained by mere ventilation—an immense saving of hand labour.

Although in the opinion of some, ventilation has diminished to a certain extent the necessity of shovel-work, it is not the less evident that the latter cannot be entirely dispensed with, and that it would be very imprudent to reduce it too much. Besides, as the qualities of barley differ according to crop and country, every intelligent maltster knows that they must be treated in different ways.

We may regard one of the largest and most recent houses now successfully working as a type of good house. In the illustrations (Figs. 44 to 46) is shown a pneumatic malting capable of working 120 quarters every day. (Scale, $\frac{1}{172}$.)

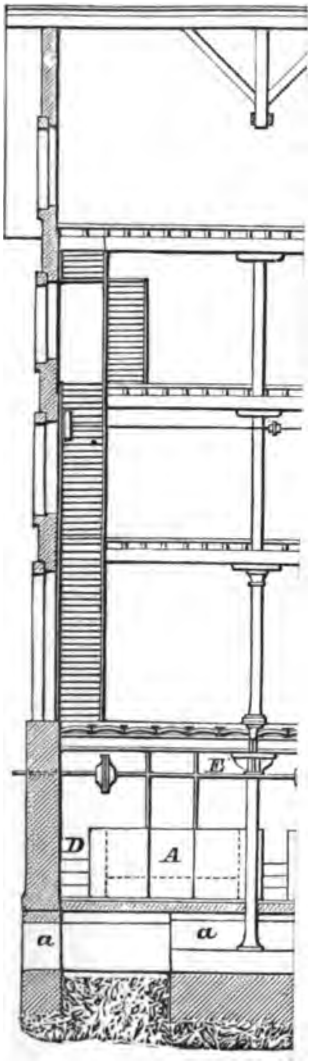
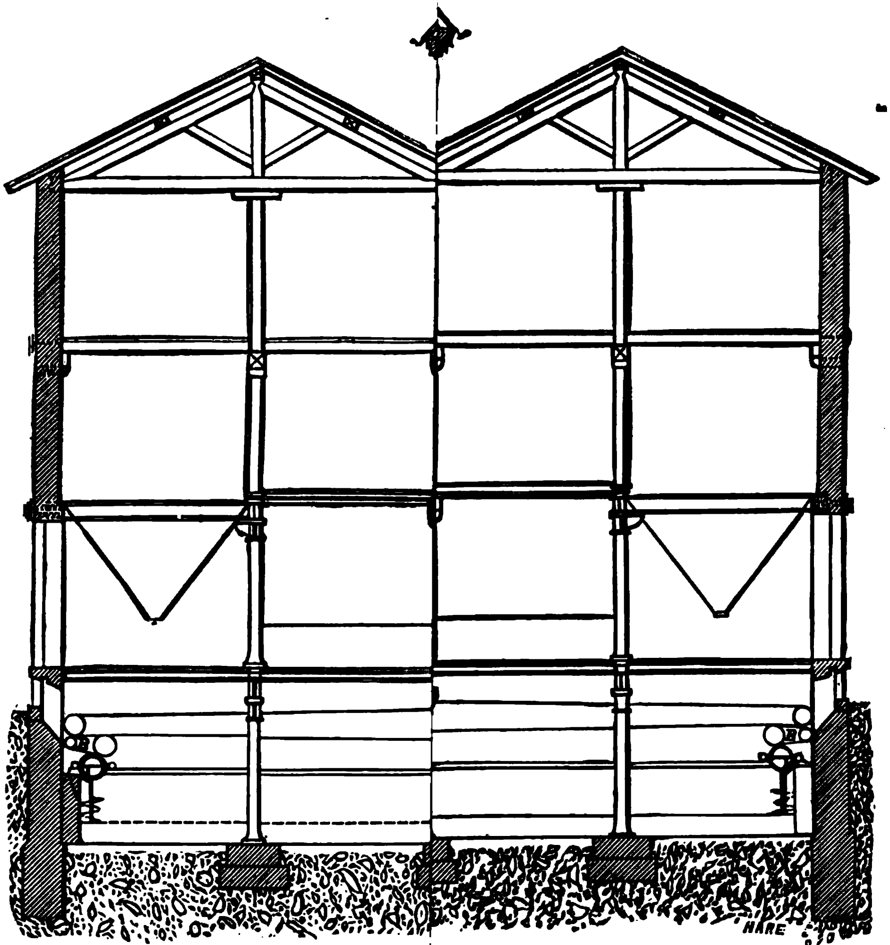


FIG. 44.—I


HARE

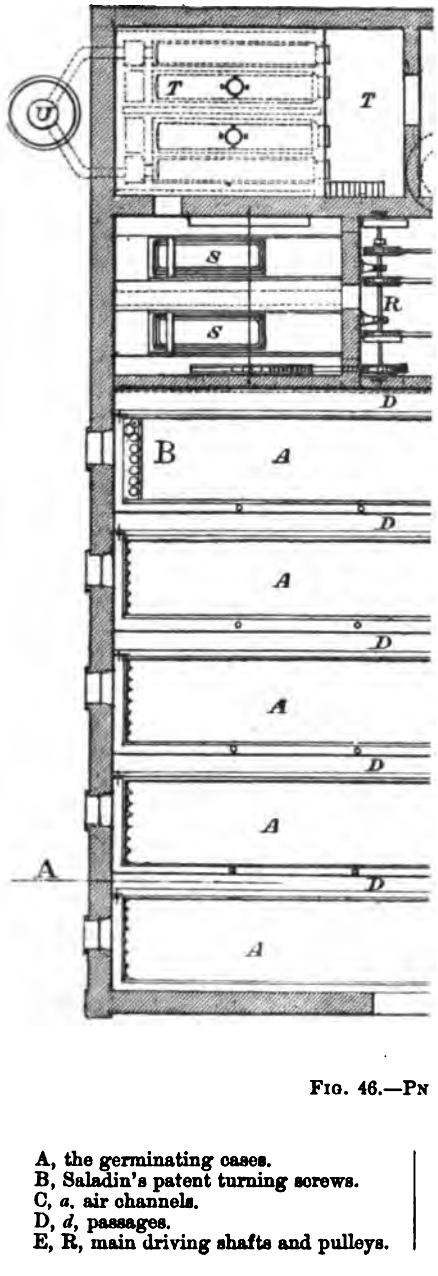


Fig. 46.—P

A, the germinating cases.
B, Saladin's patent turning screws.
C, *a*, air channels.
D, *d*, passages.
E, **R**, main driving shafts and pulleys.

The whole space occupied is the area necessary for kilns, malt- and barley-stores, engine- and boiler-house, and fans. No additional area is required for germinating-floors, as ten germinating cases, A, are placed in the basement below kiln and stores. The building is of brick, the internal walls above the ground line resting upon cast-iron columns and rolled-iron joists. The germinating cases, A, A, are of iron; the bottoms are double. The plates of the false-bottom admit of draining the corn if the germinating case is also used as a steeping cistern. Their chief object, however, is to admit of ready circulation of the air by means hereafter described. Large channels, A, *a*, serve as drains for moisture, and to convey the air to or from the growing corn. Between each case is a passage, D, enabling the maltster to have free access to the corn at all points. With the exception of the driving shaft, E, all the machinery is in duplicate, so that the possibility is remote of any breakdown that would seriously affect the working of the house. This is necessary, as should the fans, L, N, be stopped for twenty-four hours, the corn germinating at a depth exceeding thirty inches would inevitably heat and be spoiled. The boiler, T, and the engines, S, are of the common type of twenty-horse power nominal. The fans, L, N, are the Farcot patent. The lower floors of the kilns are provided with the Schlemmer patent mechanical turners.

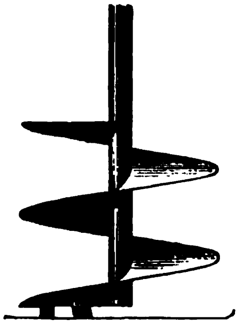


Fig. 47.
Saladin Turning Screw.

The turners in the germinating cases are Saladin's patent. (See Figs. 47, 48.)

The germination of the grain is effected by cool, moist air, forced by the fan described, after passing through the cooler and moistener known as an échangeur. As the germinating grain has a depth of from thirty to forty inches, some pressure is required, and mechanical means are necessary for efficient and economical turning.

The échangeur is a very ingenious utilisation of the well-known rapidity of evaporation of any liquid, when spread out in very thin layers over large surfaces and exposed to a current of air.

It consists of a cylinder or series of cylinders of increasing diameter placed one within another. Each consists of finely perforated sheet-iron. They are placed in a trough of water, just sufficiently immersed to ensure complete wetting. When rotated at a slow speed the surfaces of all the cylinders are kept just moistened. A volume of air is either driven or drawn through, as may be required for any particular purpose. The air in its passage comes first into contact with the moistened cylinders, and, if hot and dry, becomes damp and cool, for the constant evaporation upon the cylinders has a very considerable refrigerating effect. This was well known to the Egyptians over four thousand years ago, and the porous bottle, gargouleh, of Esneh, has been made right down to the present day to keep the drinking-water of that hot country cool and fresh. The

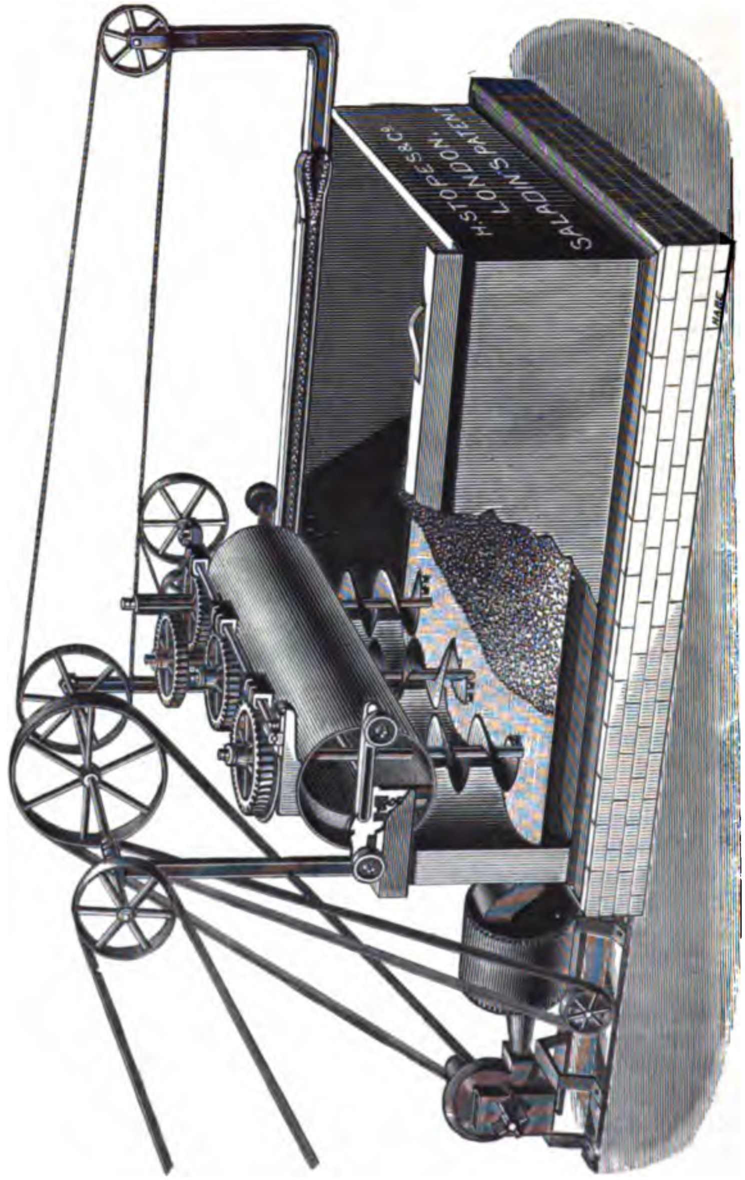


FIG. 48.—SALADIN'S TURNING SCREWS IN GERMINATING CASE, WITH ECHANGEUR AND GEARING.

échangeur is like a gigantic gargouleh, and by increasing the size and number of the cylinders and causing the water in the moistening trough to circulate, any volume of air can be wetted to the saturation-limit corresponding to its temperature, and reduced to the actual temperature of the water or glycerine used.

It will be seen that this apparatus gives the maltster complete control of the humidity and heat, as well as volume of the air driven through germinating corn.

The Saladin turning apparatus consists of a cylindrical frame provided with rollers which run on rails at the edge of the germinating-cases (Fig. 48). It is carried to and fro from either end of the case by compensating rope-gearing, which at the same time gives motion to the turning screws. These screws do not quite touch the bottom of the germinating case, but just skim it. The cases are generally made wide enough for six turning screws (Fig. 47).

The kilns are double, each possessing two floors. The construction of the furnaces is of the ordinary French pattern. The arrangement of the house permits of great regularity of working. Every day 130 quarters of barley are screened, sorted, cleaned, and passed into a steeping-cistern. When sufficiently steeped the barley runs through piping into the germinating-case which in the natural order of working happens to be empty. Here it forms the couch. When it is desirable to open couch, or prevent further accession of heat, a small amount of air is forced through the grain by opening the trap-door connected with the main air-channel. This furnishes the growing corn with oxygen, removes the carbonic acid gas, and regulates temperatures of the mass of grain.

Later, the Saladin turner is put in motion for a few minutes about every eight to twelve hours. The screws in rotating upon their axes are slowly propelled horizontally. They thus effectually turn the grain, and leave it perfectly smooth. This turning process prevents matting of the roots. The regulation of temperature and exposure to air are effected by means of the cold air from the "échangeur."

When the grain is sufficiently grown, it is elevated to the kiln. For forty hours it remains upon the top floor; it is then dropped upon the bottom floor, a further charge of green corn following upon the top floor. The benefit is mutual. The bottom is maintained at an even temperature, for it is virtually plunged in an air bath, free radiation of heat is prevented, and the top surface of the malt is necessarily nearly as warm as that next the wires, which in its turn is subject to lower heats than would be necessary if free radiation from the surface were allowed. The top floor, by the intervention of the layer of malt between it and the fire, is prevented from coming into direct contact with heat of a dangerous and damaging degree. The same heat which is used to dry one floor, and in an ordinary kiln passes at once into the air as waste, is the best possible description of heat, namely, very slightly moistened heated air, to remove the moisture from the second layer of malt at a low temperature.

It is of vital importance to retain this green malt at a low heat as long as any degree of moisture exceeding, say, 15 per cent., is retained by the corn.

The degree of heat upon the kiln, and the duration of particular temperatures, rule very largely the percentage of dextrine produced by the malt, as well as the colour of the resulting wort.

A final distinct advantage of this type of kiln is the abolition of turning the drying grain, not only economising the labour, but preventing the positive injury of placing dry malt above that which is damp through the inevitable absorption of a portion of the moisture,

All the best of the screens, sorters, and other apparatus, described in Chaps. XVI. and XVII., are employed in maltings of this class. The chief difference is that in our English maltings it is the exception to find them, whilst in pneumatic houses it is unusual for them to be absent.

The advantages of the Saladin or any other really good system over that hitherto working in Britain are numerous, the one disadvantage being the necessity to employ so much more power. They are as follows:—

1. The area occupied by the building does not equal one-third of that otherwise required. The actual growing-floor space is only about one-seventh.

2. The number of workmen (ruled necessarily by the size of the house) is reduced two-thirds.

3. The use of plant and premises is continuous, the process of malting being equally well performed during the summer months. The further advantage of this is that brewers secure entire uniformity in age of malt, while by the English system the stock of finished malt necessarily fluctuates largely.

4. All growing corn is subjected to the same conditions of surrounding air, exposure, and temperature.

5. The volume of air supplied to the germinating corn is entirely under control, as are also its temperature and humidity. When germination is arrested and the green malt is drying, the double kilns ensure control of the temperature of the corn in the kilns. The infrequency of turning the germinating grain benefits the growth of the roots and the development of the plumule, besides saving much labour.

6. Few grains are crushed or damaged by the feet or shovels of the workmen.

7. The air supplied to the corn can be inexpensively freed from disease-germs and impurities.

8. The capital needed for malting can be reduced by the diminished cost of installation, the reduced stocks of malt in hand, and wages paid.

9. The quality of the malt made is considerably improved.

10. The percentage of acidity is much reduced. The stability of the beer is increased, and a greater percentage of the ex-

tractive matter of the barley is obtainable by the brewer or other user of the malt.

These advantages must eventually be recognised.

The diagrams (Figs. 49 and 50), taken from actual workings of the system, are of interest.

The two first are instances of neglect and bad management, chiefly of use in showing the great control over temperature the method adopted by Saladin possesses of cooling and forcing air.

The dotted line indicates the movements of the valve, and the plain line the corresponding fluctuations of the heat.

The more complete diagram (Fig. 51) gives full details of two modes of working.

Ventilation was effected by blowing, the air passing through the corn from below, and being kept at a suitable temperature and humidity by M. Galland's apparatus.

A. Weight of 200 kernels in the Saladin apparatus.
B. (Dotted line) weight of 200 kernels in ordinary system.
C. Progress of chitting up to 98 per cent.
D. Cubic feet of air per minute (35 to 50 per square yard).
E. Increasing thickness of layer in Saladin system, 4 to 28 inches.
F. Temperature of layer (5 to 7 inches) on ordinary malt-floor.
G. Temperature of bottom of layer in Saladin system.
H. Do. top do do.
I. Do. air supplied.
J. Periods (17) of turning in Saladin system.
K. Do. (23) do. ordinary process.

The regularity of G, H, and I, as compared with F, shows the great uniformity of the mechanical system, and the ease with which it is controlled. The range of temperature in the layer was but four or five degrees.

On being laid in the cases on the first day, the corn was not ventilated, and the current of air was only to be introduced when the temperature had risen above 59°. But the temperature never did rise above 64°. I would here observe that ventilation caused the grain in the cases to become heavier than that on the ordinary malt-floor, thus proving that the air used for that purpose was very moist.

Germination was continued for eight days. If a lower temperature had been employed it might have continued for ten or twelve days. That is a matter which admits of easy regulation.

At the conclusion of germination a whole day is required for dry ventilation. The air employed in ventilation is constantly renewed, that which has been used being expelled. As a consequence, the resulting malt has a peculiarly delicate and pure flavour not to be found in that made without a change of air.

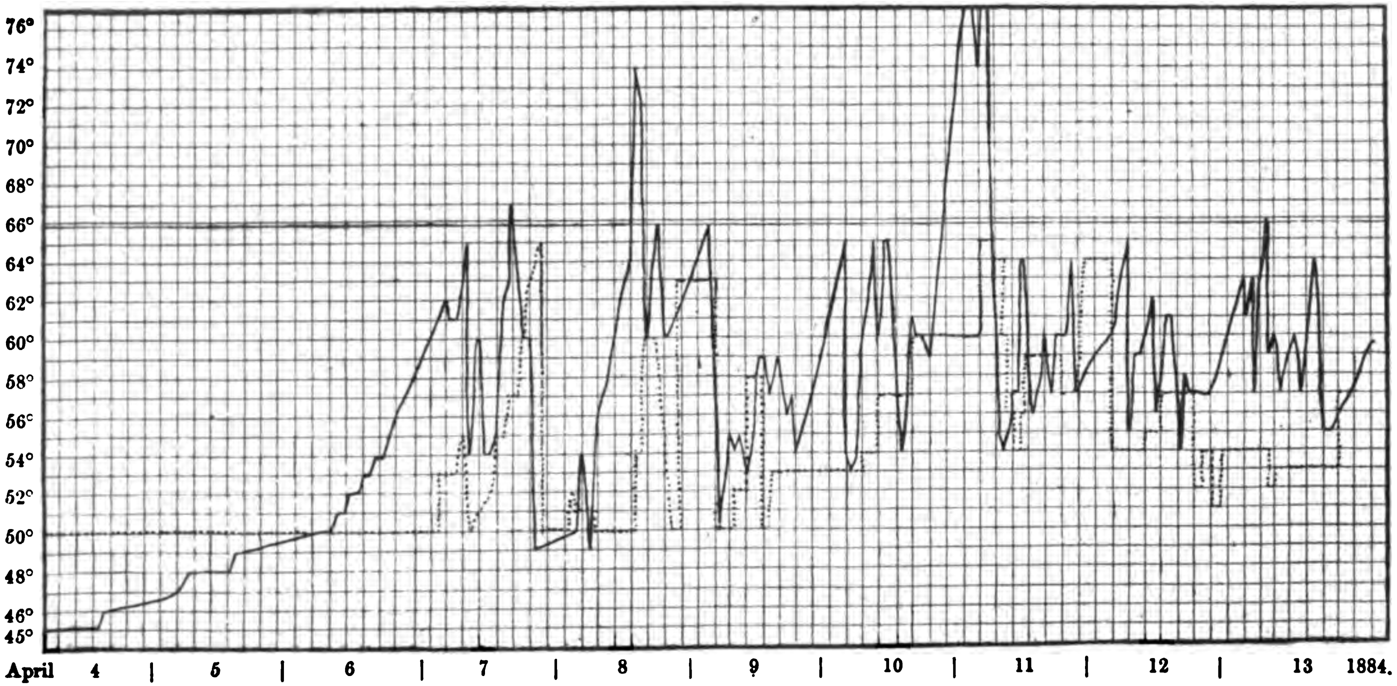


FIG. 49.—DIAGRAM OF HEATS OF SALADIN'S PNEUMATIC MALTING.

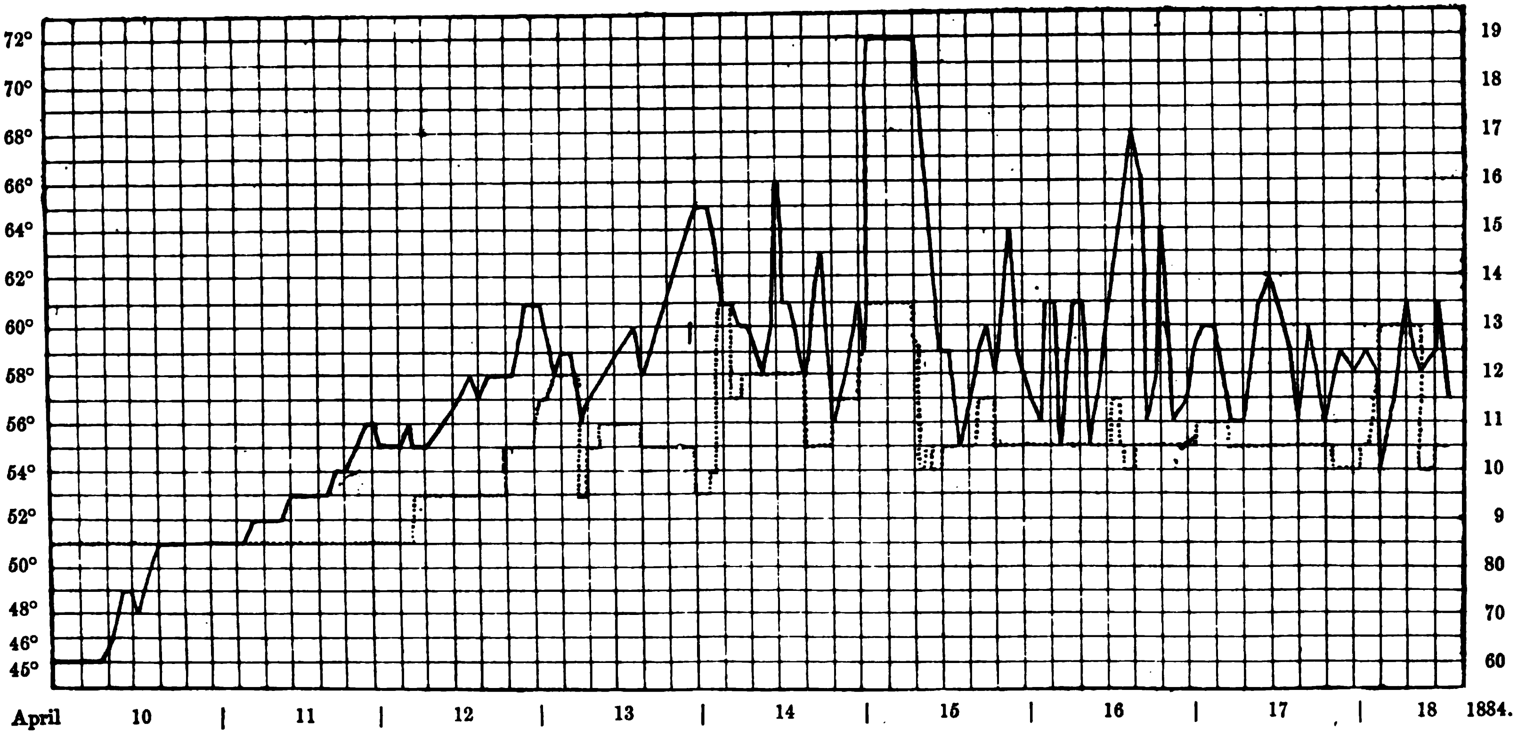


FIG. 50.—DIAGRAM OF HEATS OF SALADIN'S PNEUMATIC MALTING.

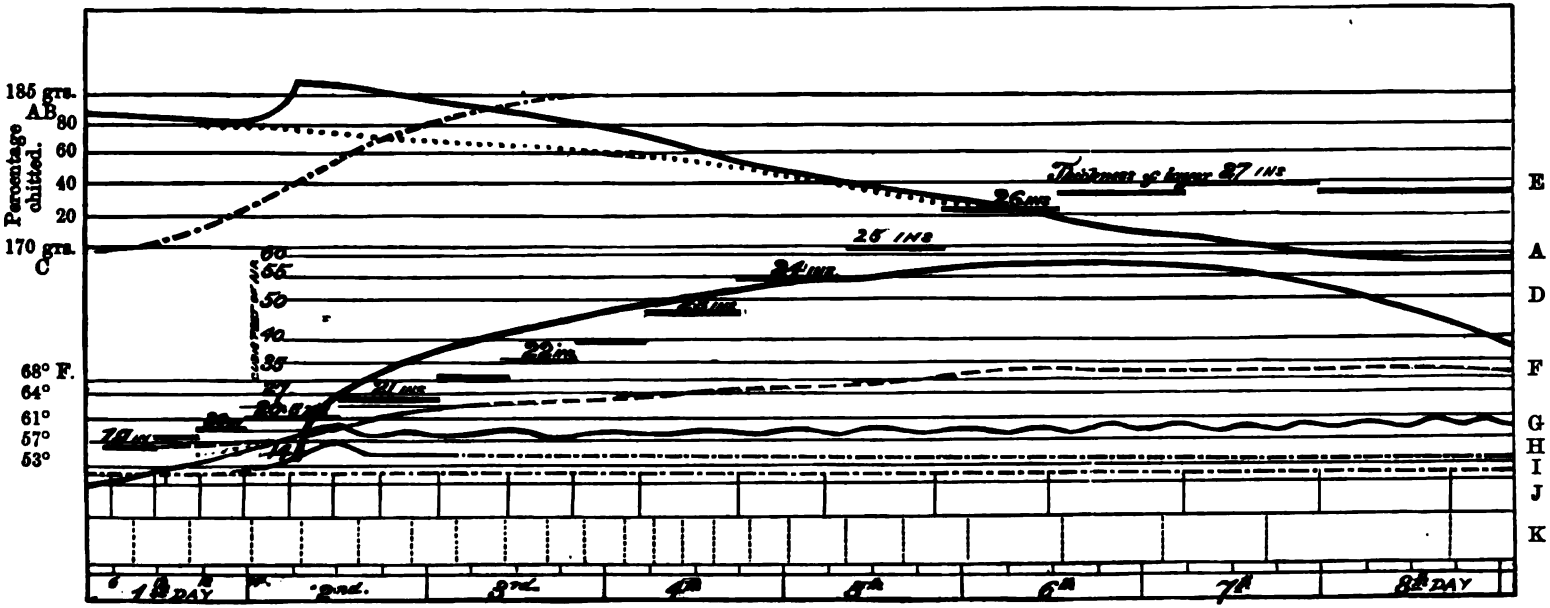


Fig. 51.

Diagram showing the progress of germination in a Mechanical Malting (Saladin system) contrasted with that on an ordinary malt-floor. 5½ qrs. of small Bohemian barley, weighing 48½ lbs. per bushel, and steeped 72 hours. Average of 8 experiments.

These houses are types of the most complete and largest yet constructed. Their existence is owing to the prior inventions of Galland, Tizard, Stead, and others.

Of these inventors, Galland stands prominently forward as the most practical, and the originator of the title Pneumatic Malting. Numerous inventions and patents have been taken out by him. His first pneumatic house was constructed at Maxeville in 1873. In this he made the mistake of allowing the grain to remain unturned during growth. This defeat was remedied in the second house constructed, which accordingly was the first successful malthouse on the new principle. It was erected for Messrs. Perry and Sons, Rathdowney and Roscrea, Ireland, and is still in very successful operation.

Since its erection several other pneumatic houses have been built in Britain, notably those of Messrs. Flower and Sons, Stratford-on-Avon ; F. Faulkner, Beeston ; Sedgwick and Co., Watford ; Nimmo and Sons, Castle Eden ; and more recently by J. Brutton, Esq., Yeovil, who has a house containing the advantages of the Galland, Saladin, and Stopes systems.

No instance has yet occurred of an ordinary English malting being converted into a pneumatic house.

The earlier types of the Galland pneumatic houses are shown by Figs. 52—54.

Figures 56 and 57 show the fuller development of the system.

The grain, steeped as usual, is placed in the couch-tanks, which are ventilated by downward suction of air. Thence the corn is discharged, through openings in the floor, into the germinating-drums, which consist of two cylinders of perforated metal or woven wire, the smaller serving as an air-conduit capable of exhaustion, whilst a fixed valve within it prevents suction of air through that part of the circumference which is not covered by the grain (Fig. 57). Short arms radiate from the interior cylinder, which revolves as one with the outer.

The advantages claimed for this system are :—

1. Reduction of cost of buildings in consequence of great depth of germinating grain, viz., 30 to 40 inches, instead of the shallow depths in open houses.
2. Practical continuance of process through the warm months, and consequent small stock of malt required.
3. Improvement of quality of malt made.
4. Reduction of working expenses, chiefly labour.

The pneumatic system must inevitably be largely, if not exclusively, used in the near future, so soon as the best type of installation can be determined. It must not be forgotten, that although for over forty years the idea has now been before the public, that the germination of malt can be best effected in this, or some similar manner, it is *only twelve years* since the first

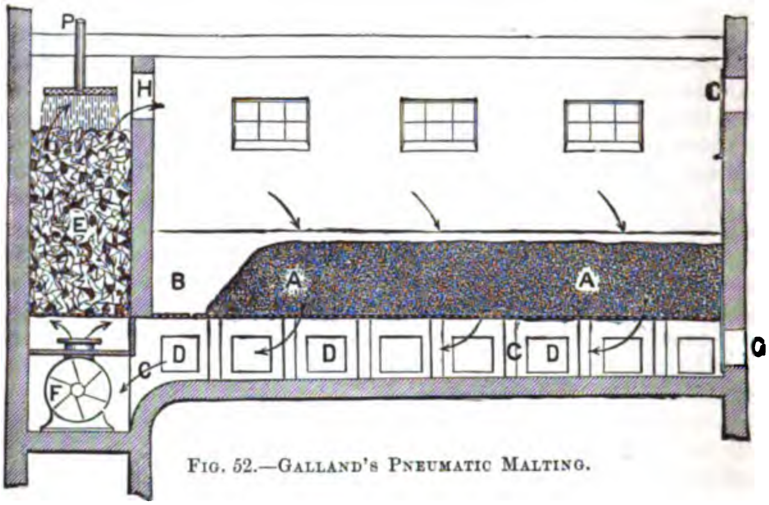


FIG. 52.—GALLAND'S PNEUMATIC MALTING.

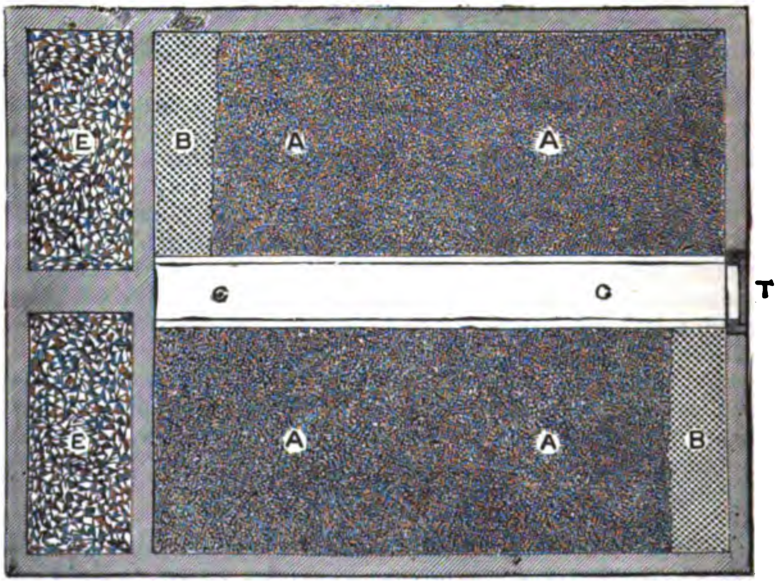


FIG. 53—GALLAND'S PNEUMATIC MALTING.

DESCRIPTION OF FIGS. 52 AND 53.

A. Germinating chambers, partly filled with grain.
B. Empty space in the same for workmen.
C. Central air-flue.
D. Lateral ditto under perforated bottoms of A, and shut off from C by slides worked from the passage above.
E. Coke chambers.
F. Fan, drawing air from central air-flue.
G. Windows with slides to regulate or prevent entry of fresh air.
H. Openings by which air from the coke chambers passes to the germinating corn.
P. Pipe sprinkling coke in E.
T. Door into central air-flue.

really practical effort so to work has been made. Owing to personal and peculiar circumstances, the practical adoption of the principle has been much interfered with and retarded.

Another form of pneumatic malt-house is one in which, in practice, the pieces are turned every twelve hours, and passed so far onwards that in the foremost place freshly-steeped barley can be continually placed, and thus the work goes steadily on until the kiln is reached. By this method, in every stage of its progress the barley is under the control of the eye, and its condition is ascertained by the aid of the thermometer. By this system the strictest cleanliness can be preserved.

On this system there has been at work, since May, 1882, at Herr Johann Schilcher's establishment at Puntigam, near Graz, a malthouse constructed according to the plans of C. Völkner, civil engineer.

The following account of this house has been largely taken from a report upon it given by Dr. Lintner in The American Brewers' Journal, March, 1883. Including the growing-floor, two kilns, a silo and scouring apparatus, it has been calculated for an annual production of 20,000 hectolitres (7,000 quarters) of malt per annum.

The total volume of each piece amounts to 15 hectolitres. As every day the work, as well as the addition of new malt, is repeated twice, we have in ten days 2 × 15 × 10 = 300 hectolitres (105 quarters) finished per floor. This quantity can be readily increased.

This installation requires, inclusive of the passage-ways, a surface space of 200 square metres, which is only one-third of the space demanded by the ordinary method of malting.

At an examination undertaken in July, the thermometer on the growing-floor and in the whole of the growing heaps showed an equal temperature of 11·75° C. The air outside, in the shade, was at a temperature of 25·5° C. The amount of moisture in the atmosphere of the growing-floor, determined by the psychrometer, was 96·97°, and the entire volume of air on the growing-floor was changed twelve times every hour, *i.e.*, 14,400 cubic metres of air passed through the heaps every hour, they occupying a space of 120 square metres.

Professor Thausing, of Mödling, visited the Schilcher establishment on the 26th of August, 1882, and expresses himself as follows on the subject:—

> "Altogether I was perfectly satisfied with my inspection. " The green malt I found very thoroughly opened, the leaf-" germ well developed, the root-germ, in consideration of the " unfavourable weather, not of an excessive length. The malt, " dried on a Völkner kiln, with a view to the kind of beer to " be produced, of a pale colour, must, according to its external " appearance, be pronounced very good."

The working in a pneumatic malting is exceedingly pleasant. In consequence of the infrequency of turning, the germ is well preserved and labour is saved. In Puntigam the chief maltster superintended the process. It is necessary that whoever does this is a thoroughly reliable man, as the regulation of the air-current above all things influences the quality of the green malt. Twice every day three men are occupied for a short time in shovelling the malt from one cell to another, in filling two cells with fresh malt, and transporting the green malt from two other cells to the kiln.

While in the open pneumatic malting the entire growing process is consummated under the maltster's eyes, who can at any moment interfere and regulate it, the opposite is presented in the mechanical malting. In this apparatus, during the entire course of the germination, the grain is contained in closed vessels very difficult of access, and difficult to keep clean, in which the process of growth can only be ascertained by means of the examination of samples. In addition to this, in most mechanical growing apparatus, the access of air is less complete than on the ordinary growing-floors. Its ingress is partly obstructed by the devious passages; as in the apparatus constructed on the Gecmen plan, the multifarious perforated tin plates, lying one over the other, prevent the regular passage of the air, which always prefers an open passage where it exists.

The greatest fault, however, in the mechanical maltings is the uncleanliness inseparable from them, many of them containing totally inaccessible corners and angles, in which mould finds all the conditions favourable to its growth.

"For the above reasons," said Völkner, "the mechanical
" method of malting, after about ten years of effort, could not
" find a foothold in brewing, and of the many isolated apparatus
" that have been set up, a large proportion have already been
" abandoned."

Although Lintner agrees with Völkner's opinion of mechanical malting, it must not pass unnoticed that during the past few years many important improvements have been made therein.

Just as strongly as against the mechanical growing apparatus does Völkner express himself against the continuous-working mechanical kilns, claiming that mechanical treatment in the kilning process is opposed to all right principles.

A vast amount of ingenuity has been exercised to invent machines that will rotate the germinating and drying grain by power.

Should it ever be brought to a practical issue, this system might advantageously be termed the Rotatory System of Malting.

Of the numerous futile efforts to effect this I need say but little.

In America, Howe's portable malting system has been brought out, but of its success or otherwise it is difficult to obtain precise information.

The illustration, Fig. 54, and the inventor's claim of advantages, sufficiently set forth the nature and merits of the invention.

The many advantages claimed for it are :—

1. The original cost of the plant is less than under the old system, and the space required in the building is greatly reduced.

2. It can be cheaply and conveniently applied in any building fitted up for the old process, and will save a considerable portion of the room. It is adapted to any and all old malting-floors, and to any ordinary building.

3. It purifies the germinating- and drying-floors or surfaces by fire, thus effectually destroying all fermentation, mould, and insect-life, and rendering the floors perfectly sweet and clean at all seasons of the year. This fire-purification is effected without expense or inconvenience, and is incomparably superior to any other method of purification ever before devised for this purpose.

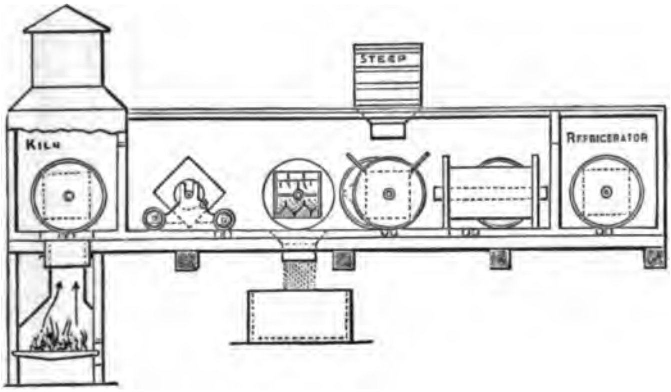


FIG. 54.—HOWE'S PORTABLE MALTING APPARATUS.

4. It places the control of the germinating and drying temperature absolutely in the power of the operator at all times.

5. By reason of the fire-purification and the perfect control of the temperature, it renders malting practicable in hot or cold weather, without regard to climate or season.

6. By this system the grain is not shovelled at all, and hence all loss and injury by trampling is avoided.

7. The grain is germinated and dried evenly and perfectly.

8. The inconvenience and injury to the men from working in the high temperature of the drying-room is avoided. The men are only subjected to ordinary temperatures during their work, whether germinating or drying the malt.

9. The grain is germinated and dried on the same floor or surface, so that no re-handling is necessary before the process of drying.

10. It is estimated that, by this system, one man can easily do the work requiring twenty men under the old systems.

11. The enormous reduction of skilled labour will, therefore,

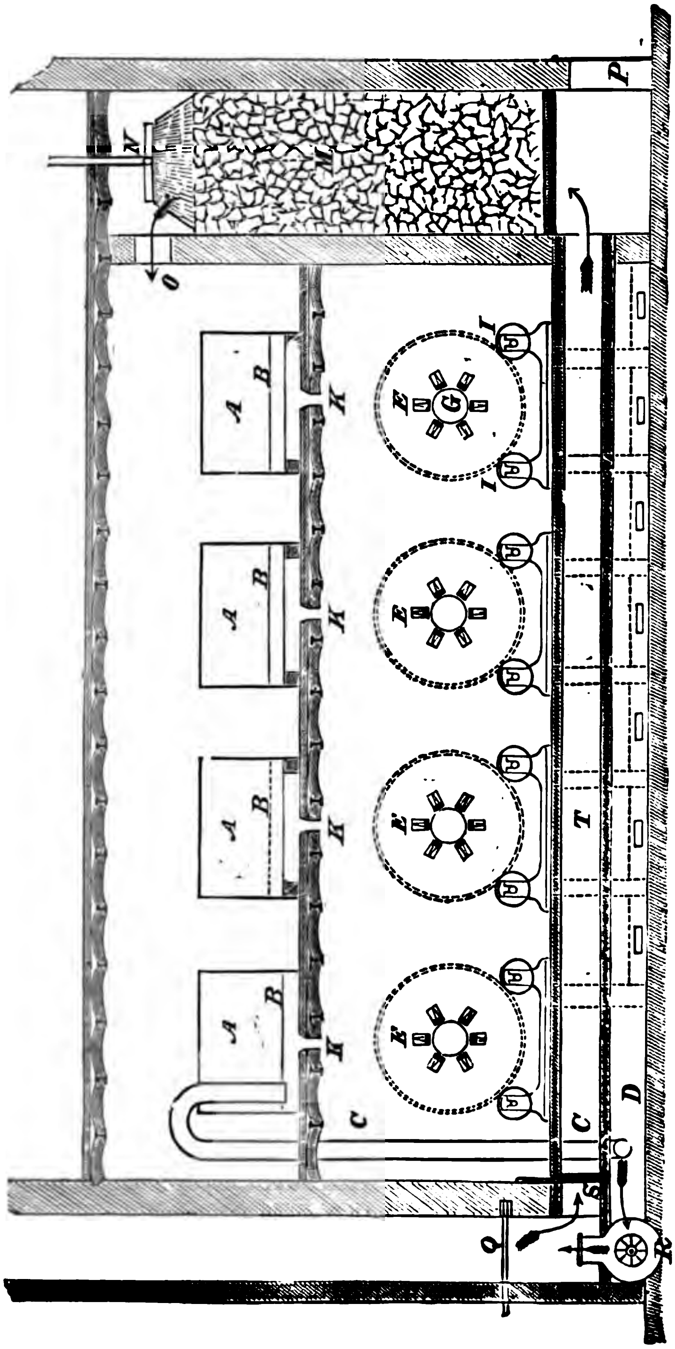


FIG. 56.—GALLAND'S PNEUMATIC MALTING, LONGITUDINAL SECTION.

be readily appreciated. One or two skilled workmen, with a few ordinary labourers, can handle the entire malting business for a large establishment.

12. At all parts of the process, ample provision is made for lightening up, overturning, and thoroughly aerating the grain without breaking or injuring it, and without the possibility of its matting or growing together, or becoming sour or otherwise impaired in quality. All this work is effected in the simplest, most convenient, and economical manner.

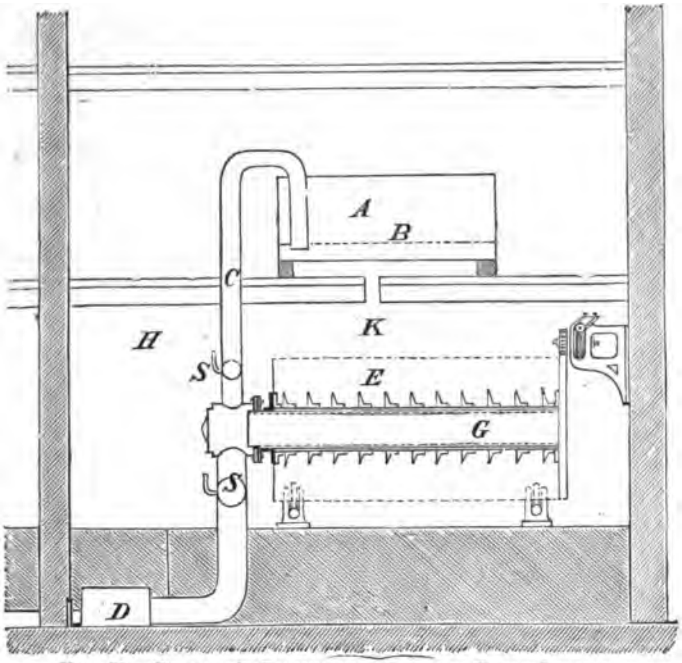


Fig. 55.—Galland's Pneumatic Malting, Cross Section.

Description of Figs. 55 and 56

A. Steep-tanks.
B. False-bottoms of ditto.
C. Pipes exhausting air from steep- or couch-tanks.
D. Air-flue, into which C delivers.
E. Germinating-drums.
G. Central cylinder of ditto.
H. Growing chamber.
I. Friction-bearings of drums.
K. Apertures for shooting grain from couch-tanks.
M. Coke-chamber.
N. Coke-sprinkling pipe.
O. Passages for air from coke-chamber to couch-tanks and germinating-drums.
P. Regulating slides for ingress of air from without.
Q. Ditto for expulsion of air.
R. Fan.
S. Valve to return same air into house.
T. Air-flue from fan to coke-chamber.

13. The machinery employed in the process is simple, and can be understood and operated by any ordinary labourer. It

is also of the most durable character, and requires but little power. No increase of power will be needed in any ordinary establishment.

Other systems of rotatory pneumatic malting are known chiefly by the name of their inventors, as the Marbeau, Golay (Paris), Fischer (Gratz), Völkner, Mantner, Markhof (Vienna), Hrnby, and Heindl (Prague), &c., &c. These have been all supplemented by a further invention of M. Galland, of which the following particulars furnish a description.

M. Galland, after lengthened experiment and numerous trials, decided to adopt a system of application of slowly-moving cylinders in preference to fixed flat floors. An earlier form of this system is shown by Figs. 55, 56 and 57.

The most recent invention is illustrated by Figs. 58 and 59. These cylinders are each of a capacity equal to one day's steep;

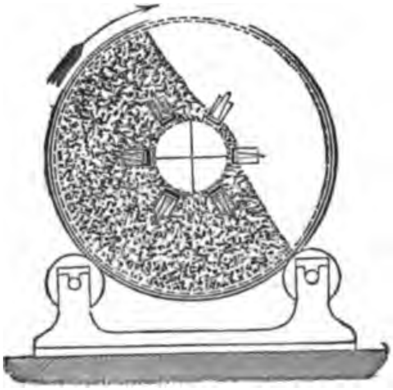


FIG. 57.

accordingly, a malting would have at least twelve of them arranged in a floor below the steeping-cisterns.

The corn, after steeping, is dropped into a cylinder, in which it is kept moving as much as is necessary, and is supplied with air, hot or cold, wet or dry, as the circumstances of the growing grain demand.

When sufficiently grown, the cylinder itself is removed bodily into the kiln, and the drying is effected within it. (See Figs. 58 and 59.)

The following elaborate tables, showing the cost of the erection and working of three different processes, have been prepared by M. Galland. Although I do not admit the accuracy of all these calculations, on the whole they are worthy of the careful study of everyone interested in the matter. The cost of installation-charges for workmen and values of product necessarily may vary from the actual facts known to maltsters. Still, on the whole the comparison is a fair one, and the result is approximately correct.

Comparative Table of Maltings on Different Systems in Relation to their Installation and Fabrication.

General Information.	Treatment—Working of 2,500,000 kilos a year.			Treatment—Working of 10,000,000 kilos a year.		
	Maltings.			Maltings.		
Remark. All the sums for the materials, construction, and fabrication are established on the standard prices of Paris.	Pneumatic with Cylinders.	German.	English. Old Plan.	Pneumatic with Cylinders.	German.	English. Old Plan.
1. Number of working days a year for a good malting	355	210	210	355	210	210
2. Quantity of barley employed each day in kilos	7,100	12,000	12,000	28,400	48,000	48,000
3. Surface of the buildings of the establishment with malt- and corn-pits or bins	600	2,700	2,800	2,300	10,800	11,200
4. Surface of the buildings of the administration	200	200	200	400	400	400
5. Surface of the yards and passages	1,500	2,000	2,000	1,850	3,600	3,600
6. Surface total necessary for each malt-house	2,300	4,900	5,000	4,500	14,800	15,200
7. Capacity of the pits in iron or bins for barley and malt in cubic metres	1,200	2,000	2,000	4,800	8,000	8,000
8. Steam horse-power employed for water-pumps, moving the grains, and for ventilation	18	8	8	60	30	30
13. Price of the land at fifteen francs the metre and eight per cent. law expenses	37,260	79,380	80,000	72,900	239,760	246,240
14. Price of the iron pits	22,500	37,500	37,500	90,000	150,000	150,000
9. Number of working men for the whole service	9	30	30	36	120	120
10. Number of days work during the fabrication	3,195	6,300	6,300	12,780	25,200	25,200
11. Number of days work after the fabrication	90	620	620	396	2,480	2,480
12. Number of total of day's work	3,285	6,920	6,920	13,176	27,680	27,680
18. Rolling or working capital necessary for 100 days working at twenty-five francs per 100 kilos of barley	177,500	300,000	300,000	710,000	1,200,000	1,200,000
15. Net price of the buildings of the administration	50,000	50,000	50,000	120,000	120,000	120,000
16. Total net price of the establishment, including land, works, hoppers for germination, kilns, pits, cleaners, dividers, transporters, washers, buildings and administration, horses, carts and wagons, &c.	350,000	675,000	575,000	1,220,000	2,180,000	1,880,000
19. Total of capital installation and capital in use	527,500	975,000	875,000	1,920,000	3,380,000	3,080,000
17. Capital immobilised per metric quarter of barley per year	14	27	23	1,220	2,180	1,880
20. Proportion of the acidity of malt	15	25	25	15	25	25
21. Moulds	None.	Often.	Often.	None.	Often.	Often.

Comparative Table of Maltings on Different Systems in Relation to their Installation and Fabrication.

ACCOUNTS OF THE FABRICATION.	Treatment of 2,500,000 kilos a year.			Treatment of 10,000,000 kilos a year.		
	Malt-houses.			Malt-houses.		
Expenses.	Pneumatic with Cylinders.	German.	English.	Pneumatic with Cylinders.	German.	English.
1. Barley, chosen and sorted, at 22 francs the 100 kilos	550,000	550,000	550,000	2,200,000	2,200,000	2,200,000
4. Workmen at 4 francs a day	13,176	27,680	27,680	52,704	110,720	110,720
2. Coals at 2.50f. the 100 kilos at 1.5 kils. per horse and hour ..	5,400	2,417	2,417	17,134	8,567	8,567
3. Coke for kiln-drying, &c., at 3.50f. the 100 kilos (10 kilos per quintal of barley for pneumatic malthouses and 15 kilos for ordinary malthouses)	8,750	13,125	13,125	35,000	52,500	52,500
5. One chief of fabrication	3,000	3,000	3,000	5,000	5,000	5,000
6. Direction	6,000	6,000	6,000	10,000	10,000	10,000
7. Clerk of offices	6,000	6,000	6,000	10,000	10,000	10,000
9. Carters and horses	5,000	5,000	5,000	10,000	10,000	10,000
11. Interest of rolling capital, at 7 per cent., including expenses ..	12,425	21,000	21,000	49,700	84,000	84,000
10. Lighting and repairs of material, at 25f. per 100 kilos of barley treated	6,250	6,250	6,250	25,000	25,000	25,000
8. Office expenses	6,000	6,000	6,000	12,000	12,000	12,000
12. Assurances, at 1.50f. per thousand	975	1,733	1,577	3,900	5,932	5,308
13. Totals	623.011	648,205	648,049	2,430,438	2,533,719	2,533,095
Receipts.						
14. Malt at 35.50f. the 100 kilos	710,000	710,000	710,000	2,804,000	2,840,000	2,840,000
15. Germs	4,000	4,000	4,000	16,600	16,000	16,000
16. Over value for pneumatic malting at, 1.50f. the 100 kilos (minimum)	30,000	—	—	120,000	—	—
17. Totals	744,000	714,000	714,000	2,976,000	2,856,000	2,856,000
18. Difference in gross profits	120,989	65,795	65,951	545,562	322,281	322,905
19. Left for paying off interest and dividends of the fixed capital ..	34·56°/o	9·74°/o	11·46°/o	44·71°/o	14·78°/o	17.17°/o
20. Cost of fabrication per metrical quintal of barley	2.92 f.	3.93 f.	3.92 f.	2.30 f.	3.34 f.	3.33 f.

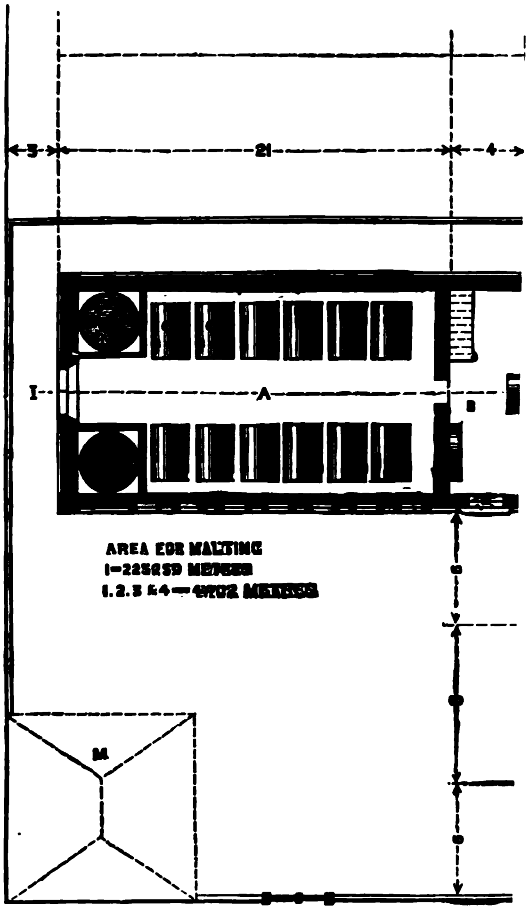


FIG. 58.—GALLAND'S ROTARY

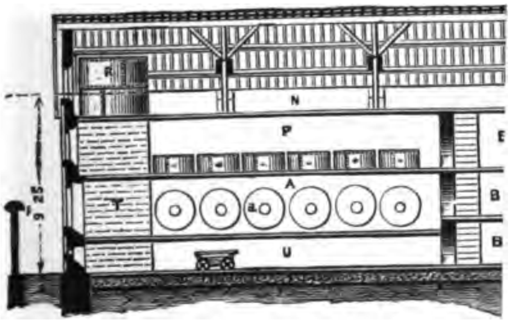


FIG. 59.—GALLAND'S ROTARY PNEUMATIC M

A very clever continental writer* states, in concise form, the chief objections that are at present urged against these forms of mechanical pneumatic malting:—

" 1. The germination of the grain is beyond control during the whole continuance of the malting process, as it is absolutely useless to depend upon single samples drawn from the chamber or cylinder. Every good maltster recognises the importance of ascertaining the temperature, humidity, and progress of growth on each part of the floor. In the middle or at one end these may be quite different to what they are at the other end or at the side next the door, whence the samples are drawn. Of this there cannot be better proof than the balling or matting of the malt, so common in mechanical malting apparatus. The opportunity of sprinkling the floors is lost too, although it is most necessary. The circulation of air of an uniform humidity is also often practically impossible.

" 2. The air-supply in most mechanical maltings is as defective as on any ordinary malting-floor, where it can be assisted by spreading the grain to facilitate aëration. The exceptionally narrow passages for the air, the number of corners and bends, at least in apparatus on Gecmen's principle of superposed perforated plates, all hinder the progress of the air, and deprive it of the requisite freedom of circulation; whence it follows that, despite the high velocity at which the air passes through the apparatus, there are stagnating strata which offer special facilities for the deposition of moisture and the growth of mould.

" 3. The greatest objection of all to mechanical malting apparatus is the want of cleanliness, inasmuch as it is almost impossible to keep every portion clean in an apparatus of which a large part is out of reach and sight. All the conditions favourable to the development of mould are present in mechanical malting apparatus, and whenever the latter is worked without more than ordinary care and precaution, this foe is sure to make its appearance, never again to be fully rooted out. There are other defects besides—such, for instance, as that the lacquer on the gutters of a mechanical malting apparatus is wanting in durability. An anonymous correspondent to The American Brewers' Journal (N.Y.), states as follows:—'When we began malting this autumn the gutters were like glass, but at the end of six weeks they began to rust as much as ever, particularly the sixteen topmost tiers; the twelve under ones appeared to resist better. Of course these rusted gutters are hard to keep clean, and offer a convenient lodgment for dust. In cold weather it might not be difficult to obviate the evil of washing down twice a day, but in hot weather, under like conditions, it would be impossible to prevent mould. I scarcely think

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* Die Mälzerei der Zukunft. *Allgemeine Zeitschrift fur Bierbrauerei und Malzfabrication*, April 1881.

" ' that my apparatus will hold out ten years against the rust, " ' with the best of care and ventilation.'

" This was the opinion of a practical maltster, who has " worked with the apparatus for two and a-half years, and " who on the whole likes the results of the working.

" To such defects must it be attributed that mechanical " malting has been so little adopted, although ten years have " now elapsed since its introduction; and it may be predicted " with tolerable certainty that, save in exceptional cases, it will " presently disappear."

The foregoing tables and data, in conjunction with the following practical directions to work a Saladin malt-house, may aid to elucidate the question for those who have no actual technical experience of it.

In a house with two cisterns and four germinating cases the steeping will occur every other day, and, consequently, once in each cistern every four days. One case will, therefore, be charged every two days, and the top floor of kiln will be loaded with the same frequency.

In carrying this out the ordinary routine of work must accordingly be as follows:—

First Day.

Unload bottom floor of kiln.

Discharge top floor to the bottom or finishing floor.

Load green malt to top floor.

Thoroughly clean and wash germinating case.

Discharge steeped corn from cistern to case.

Clean cistern.

Attend to all germinating cases, fan-turners, échangeur, and whatever may be necessary in house.

The work of attending to cases, &c., embraces the record of all temperatures. This is preferably done every hour, and it is decidedly best to keep fans perpetually at work, removing only so much air as is needed to maintain temperature of corn at the required point.

The turning of the germinating grain is requisite once every twelve hours or so. With the Saladin "retourneur" this is a simple operation.

Second Day.

The attention to kilns and floors has to be continuously given as on other days. This time is filled in with receiving, cleaning, storing, or steeping corn, and cleaning and delivering finished malt.

The practical directions for all the varied processes involved necessarily vary in every house.

For best record of work, see Appendix.

Reviewing the present position of pneumatic malting, it seems very probable that it will be ere long very extensively and generally adopted. Especially is this to be expected in smaller houses working upon the improved pneumatic system of hand-malting, and in great houses by the Saladin system.

Examining the defects of hand-malting, the chief impediments to a satisfactory result lie in the inequalities of temperature and humidity in the malt on the growing-floors. Heat is abstracted from the topmost layers by evaporation, conduction, and radiation, assisted by a natural process of ventilation, by which the warmer air rises and gives place to the colder strata of fresh air; whereas the under layers of grain part with this heat by conduction only.

If, however, the floor is perforated, and the pressure of the air below it is sufficiently reduced to cause that above the floor, together with the carbonic acid gas, to seek a passage downwards through the grain, thereby the evaporation is reduced and uniform humidity in the grain is secured.

This is pneumatic malting in its simplest form, and to Herr J. C. Jacobsen (Carlsberg) the credit is due of having taken up this system, and given to it a certain degree of practical development.

In this system we have all the advantages of hand-malting combined with much more perfect artificial ventilation, whereby the purity, relative humidity, and temperature of the air are completely under the maltster's control, where nothing is out of sight, where the most scrupulous cleanliness is easily practised, and where the work can be carried on at any season of the year. Apart from the advantages which pneumatic malting ensures in the quality of the produce and the certitude of the results, the facility with which the work proceeds increases the capacity of the floors five-fold, so that whereas, according to the present system of hand-malting, with a ten-day malting period, 100 quarters of finished malt require 4,000 superficial feet of floor-surface, on the pneumatic system 800 feet suffice.

The conversion of an ordinary malting-house into a pneumatic one, with due care and skill, is a very simple affair, which needs no complicated apparatus, and can be carried out at comparatively small cost, taking into account the increased capacity of the floors.

A further advantage in the pneumatic system, is that it can be introduced without imposing the necessity of any extensive changes, which in itself is yet another proof that it is justifiable to regard it in the near future as capable of much extension.

CHAPTER XV.

CAPACITIES AND COSTS.

Capacities: Dimensions of Stores, Cistern, Couch, Growing-Floors. Kilns: Barley-Kilns, Fires, Inlets, Outlets, Coal. Engines. Elevators. Screens. Costs. Weights.

THROUGHOUT this work, in various places, dimensions and capacities are alluded to or directly stated. A short concise chapter devoted to the subject may prove a convenience to readers.

Space-areas throughout maltings vary materially, even in maltings owned by the same individuals, situated in close proximity, and worked in the same manner. So wide are some of these differences, it seems almost futile to strike an average. Hence it is a question in which personal experience has a direct value, especially if the experience has been bought, and the knowledge of the whole subject acquired, in many lands and climes.

Houses working in a good manner, upon the ordinary English and Stopes' systems, require certain spaces to be duly proportioned. Without laying down the exact dimensions in a dogmatic manner, the following particulars have been found to work well in many places widely scattered throughout Britain and elsewhere.

GRANARIES.

Corn- or barley-receiving-rooms and stores should be sufficiently large and commodious duly to receive, screen, and store from four to six months' consumption—*i.e.*, a house steeping thirty quarters three times a fortnight, or fifteen quarters every two days, will steep in four months from 720 to 900 quarters barley. In many districts such a house would require to store, by the end of December, at least 800 to 1,000 quarters barley.

In other districts, Ireland for instance, much larger storage capacity must be provided. In certain corn-centres, or seaports, much less barley need be stocked as fresh cargoes can be purchased, or corn secured, at all times and seasons. Still a fair storage-capacity is of value when prices are unsettled, or abnormally low.

With pneumatic houses still larger capacity is essential, as it would happen, in many districts, that all the corn for the season must be bought by February. This necessitates the storage of seven or eight months' consumption.

A house steeping thirty quarters every other day would thus need a capacity of over 3,000 quarters.

The majority of maltsters would, of course, prefer falling back upon foreign supplies, in preference to this very large store of corn, although it should not be overlooked that it is always preferable, and less harmful, to store barley than malt.

In addition to the actual space needed to store a given bulk of barley, it is also requisite to allow some room for cleaning and sorting purposes.

It pays also to attend to the separation of different growths of corn.

Small bins, holding from twenty-five to fifty quarters each, are, as a consequence, desirable. A large number of small bins is distinctly preferable, for many reasons, to a small number of large bins.

A large growth or bulk of a particular class of barley can be put into several small bins without loss or trouble. A small growth, or a mixture of several growths, must either be mixed with more corn, and loss is inevitable, or a great loss of space occurs.

Undried corn should never be heaped to any depth exceeding 4 feet, unless it is known to be very dry.

An average quarter of barley weighs nearly 4 cwt., and occupies almost 10¼ cubic feet (10·24 feet).

Accordingly, 1,000 quarters barley weigh 200 tons, and occupy an area (at 4 feet deep) of 2,500 feet.

MALT-STORES.

Commonly a malt-store holds from four to six months' output of malt. A house in which fifteen quarters are steeped every two days will occasionally have accumulated within it in six months over 1,300 quarters of malt.

A pneumatic house ought not to accumulate three months' "make."

No objection can be raised to putting malt into deep stores. In many cases it is desirable to have small but deep bins.

No partition or boarding should be *fixed* in a malt-store upon any pretence, excepting the splines on walls and rightups needed to form divisions. Where practicable, these are also better portable.

In malt-stores room has generally to be provided for rounding up or heaping from kiln, treading, and screening.

One-fourth the area of kiln-floor commonly suffices for these purposes.

In maltings of a capacity exceeding thirty quarters steep, it is always better to keep the malt-store entirely distinct from granaries. The best plan, when practicable, is to make it a distinct and separate building.

The capacity has to be ruled by local and special requirements.

A quarter of malt weighs only 3 cwt.

CISTERN.

Many people allow 12½ feet per quarter steeped as the limit of capacity of cistern. This, however, is not enough. It is not wise to allow less than 14 feet per quarter. Thus a house wetting fifteen quarters every other day requires two cisterns, each of a capacity of at least 210 feet. A thirty quarter house, working twice a week, requires one cistern of 420 feet.

COUCH.

Where a couch-frame is formed, a capacity of 14 to 15 feet is requisite. When a cistern wets for two floors, it is preferable to construct one couch-frame, and to open out for the second-floor. Each cistern must, however, have a couch-frame, if placed on different floors. When two cisterns come together, one couch-frame suffices for both cisterns.

Thus in a house wetting thirty quarters every four days, a couch-frame is needed of a cubic capacity of about 450 feet, or possessing a superficial area of 180 feet. This would be 6 feet wide and 30 feet long.

If in the same house fifteen or sixteen quarters were wetted every two days, the couch-frame would be only 225 cubic feet, or 90 feet area. This would be 20 feet long by 4 feet 6 inches wide, or any other suitable and convenient dimension.

FLOORS.

In calculating floor areas it is necessary to recognise many contingencies of position, site, mode of use, &c. If, however, 200 feet per quarter steeped be allowed, and the capacities of cisterns and kilns are liberally calculated, a floor can be made to work properly to its full capacity under all circumstances.

Thus, if a house is intended to wet fifteen quarters every other day, or thirty quarters four times a fortnight, and 6,000 feet of floors have been constructed, it will often happen in cold sharp weather, and with certain barleys, that the actual capacity of the house is thirty-eight to forty quarters. By working it fully, if the floors are of good proportions, so much as twenty quarters every other day could be safely and properly grown upon them. In some districts even more could be worked by some men.

Probably 180 feet per quarter is the safest general average space.

KILNS.

Ford says:* "Kilns should not have less than 20 super-"ficial feet for every quarter of malt to be dried, to be

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* FORD, Malting and Brewing, p. 137.

" enabled to dry off the entire steeping at once. But if " 25 feet be allowed the whole steep can be dried off in " three days."

Doubtless he meant by this to allow 25 feet for each quarter of barley steeped (not "malt to be dried"). If so, the allowance is not enough.

No pale-malt kiln, under any circumstances, should ever have less than 33 feet per quarter of barley steeped.

Thus a kiln drying the malt grown in a house steeping fifteen quarters every other day, must have a floor-area of 1,000 feet. This is, of course, best arranged in two floors of about 500 feet each, or say 22 feet 6 inches square.

The folly of putting ten or more inches of green, wet malt on a kiln will eventually be realised, and the practice will be abandoned.

When a separate barley-kiln is constructed, it need never be made to exceed 20 feet square, excepting for very large maltings. It is safer to allow an area of 40 feet per quarter for sweating purposes.

The heights, dimensions of fires, and areas of inlets and outlets to kilns have to be regulated each by the other. They are in turn all controlled by site and nature of malt required. Thus, for high-coloured malt, every dimension would vary from those best adapted to produce pale or white malt.

The sum-total of the inlets should exceed the outlet. Where possible, one outlet only should be permitted. The height of fire-bars should never exceed 2 feet 8 inches from the floor.

The drying-floor (unless for brown or similar malts) should never be within 10 feet of the fire-bars; it need never exceed 18 feet for the whitest malt.

The two drying-floors should never be closer to each other than 6 feet.

No pale-malt kiln should ever be less than 45 feet high. The largest kiln need not exceed 75 feet in total height.

Spark- or baffle-plates are quite unnecessary for distribution of draught or heated air in any well-proportioned kiln, possessing a good fire-place, unless a large amount of kiln-dust is allowed to accumulate upon the top of the furnace. Should such carelessness be permitted, then a baffle-plate is useful to prevent the kiln-dust firing readily and smoking the malt.

Brown-malt kilns can be made much smaller in all points excepting outlet and furnaces. 80 feet per quarter is needed to dry brown malt properly. It is, however, much to be desired that no more kilns for this purpose should ever be erected.

COAL.

One ton of anthracite coal occupies about 40 cubic feet.
,, bituminous coal ,, ,, 45 ,,
,, coke ,, ,, 55 ,,

ENGINE.

A three-horse power (nominal) engine with four-horse power boiler, or a three and a-half horse power gas-engine, can, if rightly designed and properly managed, do all the work of pumping, elevating, loading, screening, &c., of any sized English malting not exceeding 120 quarters steep. It is, however, always a mistake to employ engines of small size. An engine to work well and economically must be considerably stronger than the aggregate of the work it has to perform.

Pneumatic houses require considerably more power than other houses, as the fans and other machinery necessarily absorb a considerable amount of power. Each house should have this matter carefully calculated according to its design and method of working.

ELEVATORS.

No barley-elevator should be fixed that cannot easily raise twenty quarters per hour. In houses of sixty quarters steep and upwards, forty to fifty quarters per hour is more satisfactorily worked.

SCREENS.

A screen capable of properly grading, sorting, and cleaning eight quarters per hour, is quite large enough for any malthouse of a capacity of 120 quarters steep, or even larger. Three to four quarters per hour is quite sufficient for a ninety-quarter house.

The general dimensions of pneumatic houses are not given. No maltster will find it profitable in the end to design a house of this class without skilled assistance.

COST.

Twenty-five years ago Ford estimated the average cost of a simple malt-house at £53 per quarter steeped.* This must be exclusive of cost or value of site and tools.

It is, of course, possible to strike an average cost of houses built for any particular period; but it does not follow that such an average is the slightest guide for any particular house about to be erected.

The factors to be considered are:—Site: its intrinsic value, water-supply, and accessibility. Dimensions and character of house to be erected. Local value of materials and labour. Quality of materials employed and character of work done.

Let all these be ascertained and determined, and the cost of a house can be estimated with accuracy. Leave any one of the factors out, and the total cost may be considerably enhanced.

A plain, simple house, badly fitted and constructed, may be built, under favourable local conditions, for £50 per quarter, or even less.

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* FORD, Malting and Brewing, p. 141.

An elaborate and first-class house, badly placed, may cost as much as £130 per quarter, if site and tools are included.

A house on the Stopes' system necessarily costs less than any other, as two small cisterns cost less to make and work than one large one, and a kiln 22 ft. square must cost less primarily than another of 31 ft. square. The effective capacity of the smaller kiln would, in addition, be much greater and cost of working less.

Still, with all my experience of the subject, I cannot pretend to give an estimate of the approximate cost of any hypothetical house.

Cost of Making Malt.

The expenses of manufacture necessarily vary widely. The chief customary items are—

I. Rent, or capital outlay involved in premises, plant, &c.
II. Capital charges, working capital, loans, stocks, &c.
III. Rates and taxes.
IV. Depreciation of premises, plant, and stocks.
V. Management charges, salaries, wages, &c.
VI. Rail- or other carrying charges, porterage, &c.
VII. Fuel and other materials.

To strike an average of working charges applicable to all cases or circumstances is manifestly useless.

Thus a maltster who hires a house at 20s. per quarter steeped per annum, pays very low rates, taxes, and wages, gets all the barley delivered by growers to the malting free of charge, and who, in addition, spends no labour or money upon the cleaning of his corn, obviously makes malt at less than half the cost of another man who builds a handsome new house at a cost of £120 per quarter in a city or borough subject to high rates and taxes, in which all the corn has to pay city dues, carriage, and porterage, and the corn is all handled and graded in the most elaborate and expensive fashion.

It is possible to make malt at a nett cost of 2s. 9d. per quarter, exclusive of increase, if only actual disbursements are considered; and I know some houses in which the true cost exceeds 9s. per quarter.

	£
Thirty-quarter house costing £4,000 involves an annual charge of .	240
Depreciation of premises at four per cent.	160
Value of implements and tools, £1,000 at six per cent.	60
Depreciation of ditto at ten per cent.	100
Working capital locked up, £3,000 at five per cent.	150
Rates and taxes	40
Management and wages—supervision £100, two men and boy £150	250
Fuel, oil, bisulphite of lime, and sundries	120
Freights, porterage, horse-keep, &c.	380
Total outlay and charges..	1,500

The total output of a thirty-quarter malt-house as frequently worked is under 2,500 quarters per annum. This, accordingly makes the legitimate estimate of cost of malting, under such circumstances as the above estimate recognises, at the very high figure of 12s. per quarter.

TABLE OF WEIGHTS.

Barley, Chilian, Algerian, Smyrna, &c., from 3 cwt. to 4 cwt. per quarter.
Barley, Eastern Counties, from 3 cwt. 1 qr. to 4 cwt. 0 qr. 16 lbs. per quarter.
Barley, Scotch, from 3 cwt. 2 qrs. to 4 cwt. 0 qr. 24 lbs. per quarter.
Malt, whole, 10·24 feet per quarter, from 2 cwt. 2 qrs. to 3 cwt. per quarter.
Malt, ground, 12 feet to 12·5 feet per quarter.
Bricks, 8¾" × 4¼" × 2¾", each 7 lbs., or 63 cwt. per 1,000.
Brickwork, per cubic foot in mortar, 116 lbs., ruled by dryness, several pounds per foot.
Brickwork, per cubic foot in cement, 120 lbs., ruled by dryness, several pounds per foot.
Tiles, paving, 6" × 6" × 1" square, each 2¼ lbs., 20 cwt. per 1,000.
Slates, per square, Duchesses, 7 cwt. 2 qrs.
,, ,, Countesses, 6 cwt. 3 qrs.
,, ,, Ladies, 6 cwt.
Portland cement, 75 lbs. to 85 lbs. per foot cube.
,, ,, 110 lbs. per bushel (average).
Oak, English, 49 lbs. to 50 lbs. per foot cube.
Pine, red, 40 lbs. per foot cube.
,, yellow, 33 lbs. per foot cube.
,, fir, Dantzic or Memel, 35 lbs. to 38 lbs. per foot cube.
Water, 62¼ lbs. per foot cube.
,, 10 lbs. per gallon.

CHAPTER XVI.

TOOLS AND APPARATUS.

Tools and Apparatus—
Anemometers. Barrows. Brooms. Brushes. Cans. Chondrometers. Cisterns. Cleaners. Conveyors. Coolers. Dispersers. Echangeurs. Elevators. Engines. Fans. Filters. Fire-irons. Forcing-tray. Forks. Gauging-rods. Gelatinisers. Germinators. Graders. Hoists. Hose. Hummellers. Hygrometers. Ice-machines. Lifts. Lubricators.

The number of tools and appliances used by maltsters has very greatly increased during the past twenty years.

The list of those actually in use is already of considerable length, and it promises to augment with rapidity. It embraces, amongst others, the following:—

Anemometers.
Barrows.
Brands.
Brooms.
Brushes.
Cans.
Chondrometers.
Cisterns.
Cleaners.
Conveyors.
Coolers.
Dispersers.
Echangeurs.
Elevators.
Engines.
Fans.
Filters.
Fire-irons.
Forcing-trays.
Forks.
Gauging-rods.
Gelatinisers.
Germinators.
Graders.
Hoists.
Hose.
Hummellers.
Hygrometers.
Ice-machines.
Lubricators.
Malt-crushers.
Measures.
Microscopes.
Mills.
Pattens.
Ploughs.
Psychrometers.
Pumps.
Purifiers.
Regulators.
Roasters.
Sacks.
Sackholders.
Samplers.
Screens, Barley.
Screens, Malt.
Shovels.
Slippers.
Spargers.
Steam-boilers.
Stencil plates.
Testers.

Thermometers.
Tiers.
Treaders.
Turners.
Valves.
Washers.
Weighing-machines.

The whole of the preceding tools are not yet generally employed in English maltings, although a number of maltsters are familiar with their use. A few others not tabulated, of a costly and delicate character, are occasionally used by a very small number of men.

Some things, such as taps, lamps, mops, oil-cans, baskets, shafting, pipes, belting, &c., are not tabulated or described, in consequence of their general application.

Where practicable the present average value of each article is appended.

Cisterns and cowls have already been considered, under "Construction."

ANEMOMETERS.

Anemometers are rarely used by maltsters. They are, however, of great utility and value. By their use the true volume of air entering and leaving a kiln can be determined. The instrument that accurately gives the velocity of air-currents is the best for a maltster's use.

Very numerous forms of anemometers are in use.

BARROWS.

Several forms of barrows are in use, viz., sack-barrows of iron and wood, malt-barrows, sack hoisting-barrows, or portable sack-hoists, coal-barrows.

Sack-barrows are strong and convenient if made of wood, as Fig. 60, or of iron, as Fig. 61. The sizes vary from 3′ 4″ high to 4′ 10″, and they cost from 11s. to 30s. The best form are always provided with indiarubber tyres.

Another form of barrow frequently found useful in small maltings, is a combined barrow and lifter, see Fig. 62. With these barrows one man can shoulder a sack with comparative ease. They are constructed with a rack (as illustration), or the lift is worked with chains, ratchet pinion, and pawl. The cost of a barrow, with rack, is 50s. to 55s., and with chains from 60s. to 65s.

Another form of barrow combines, in addition, a portable weighing machine, as Fig. 63. A barrow of this description costs over £6.

A sack-holder, to keep open the mouth of sacks when filling, is also combined with barrows, but they are only rarely used. They cost 30s.

Malt-barrows vary considerably in shape, manufacture, and use. At least ten different forms are in general use in British maltings. They convey dry corn to steep, steeped corn to couch, split up couches, carry green malt forward, or to kilns, and dry malt from kiln to store, &c., &c.

An ordinary wooden or wicker trough on long bearers or handles, of any form and capacity below three bushels, can be used economically.

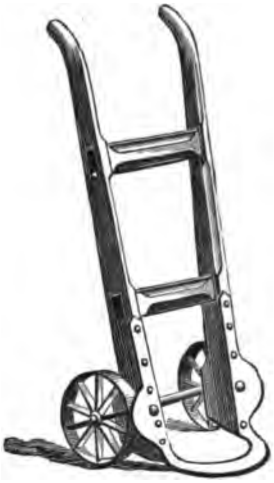


Fig. 60.—Wooden Sack-barrow.

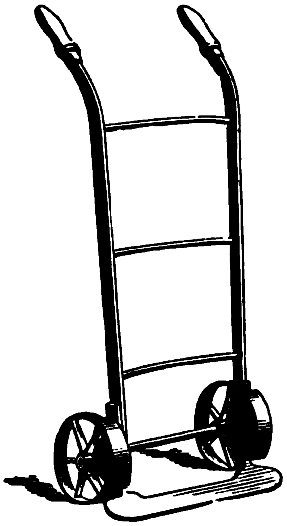
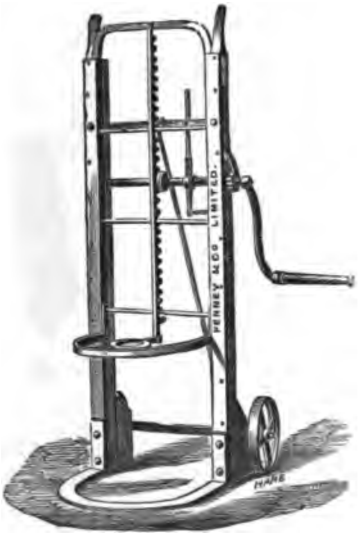


Fig. 61.—Iron Sack-barrow.

Such troughs, or baskets, are often mounted on rounded runners or bearers of wood, and dragged along the floor. This practice, at any stage of malting, is unwise and wasteful.



PENNEY & Co LIMITED.

Fig. 62.—Sack-hoist.

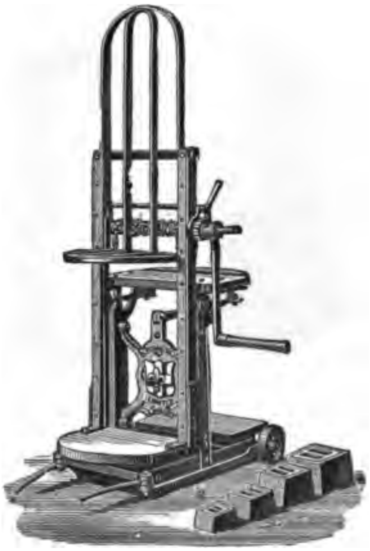


Fig. 63 —Sack Weighing and Lifting Machine.

Light semi-circular sheet-iron drums, on wheels of large diameter, with indiarubber tyres, are most liked.

Coal-barrows are any common type of wooden or iron barrow. (Fig. 64.) They are required only in maltings badly designed, or of very large size.

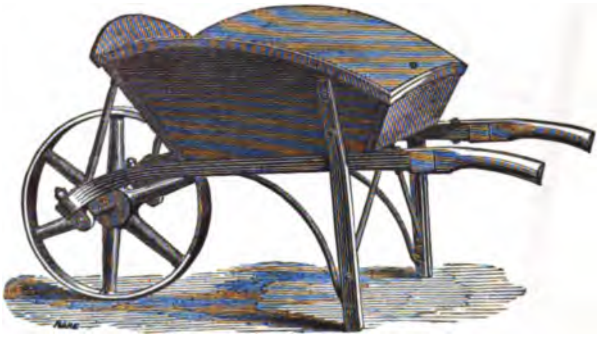


FIG. 64.—COAL-BARROW.

BROOMS.

Hair, birch, bass, and ling brooms are used by maltsters, and hand-scrubbing brushes should be used in cisterns with advantage. Long-handled Dutch hair brooms, and short hand sweeping brushes are used in malt-stores and granaries.

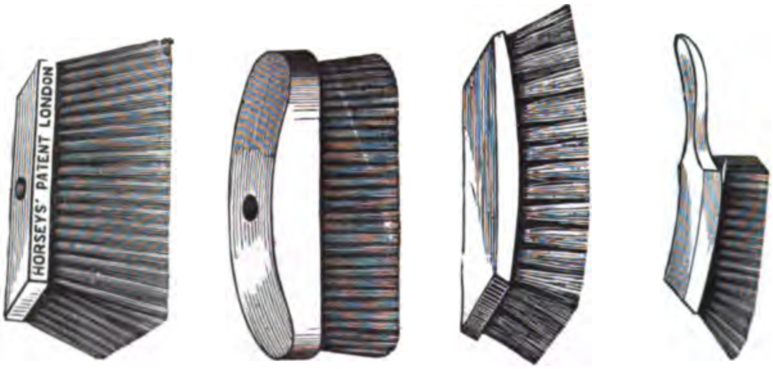


FIG. 65. FIG. 66. FIG. 67. FIG. 68.
HORSEY'S BRUSHES.

The bass brooms with the tufts inserted in solid stocks are most liked. They are known as "Horsey's patent," and are illustrated by Figs. 65-68.

CANS.

A can or watering-pot should hold three to four gallons. Two kinds are used. One with an ordinary rose for washing floors and cisterns may be used. For this purpose any type of can will do. The other is required for watering the growing grain or sprinkling, and requires a rose with very fine perforations. The form patented by Le Butt, with a long perforated spout

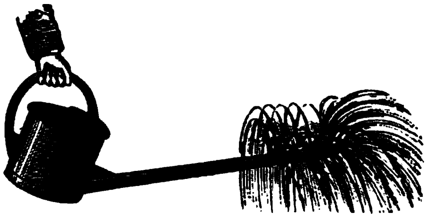


FIG. 69.—WATERING CAN.

(Fig. 69), is the best for use in every way. Water is best added to young floors in a fine spray. In very large houses a length of hose, with a fine rose affixed, is used, but unless the water-meter is carefully read, the quantity of water used is apt to be excessive or irregular.

CHONDROMETERS.—See Measures.

CLEANERS.—See Screens and Washers.

CONVEYORS.

In large maltings or granaries, conveyors are important and valuable labour-saving appliances.

Very numerous kinds have been invented, particularly in America. Three main types of conveyors exist, viz.—

1. Those that travel with the grain; belts, as Fig. 70.
2. Those that push forward the grain, as Figs. 71-73.
3. Transport-screws, sometimes called Archimedean screws, Figs. 74, 75. Of these the first are best used wherever practicable. Belts 8 to 20 in. wide running at proper speeds can carry enormous quantities of grain very great distances with the expenditure of small force.

A belt is the best conveyor of green malt from floors to kiln. At this stage malt will readily run up an incline of 45°.

The best material for loading-belts, yet found is indiarubber.

In carrying corn from screens to bins, it can be struck into any bin by a portable distributor fitted with spouts and regulating slides. (See Fig. 74.)

When a distributor is used, the belt should not exceed a speed of 500 feet per minute. When unscreened malt is carried, the spouts have to be carefully devised and set out to prevent the combes blocking.

The speed has to be regulated by the character of grain carried.

Care is also needed to arrange the guide-pulleys in the best form.

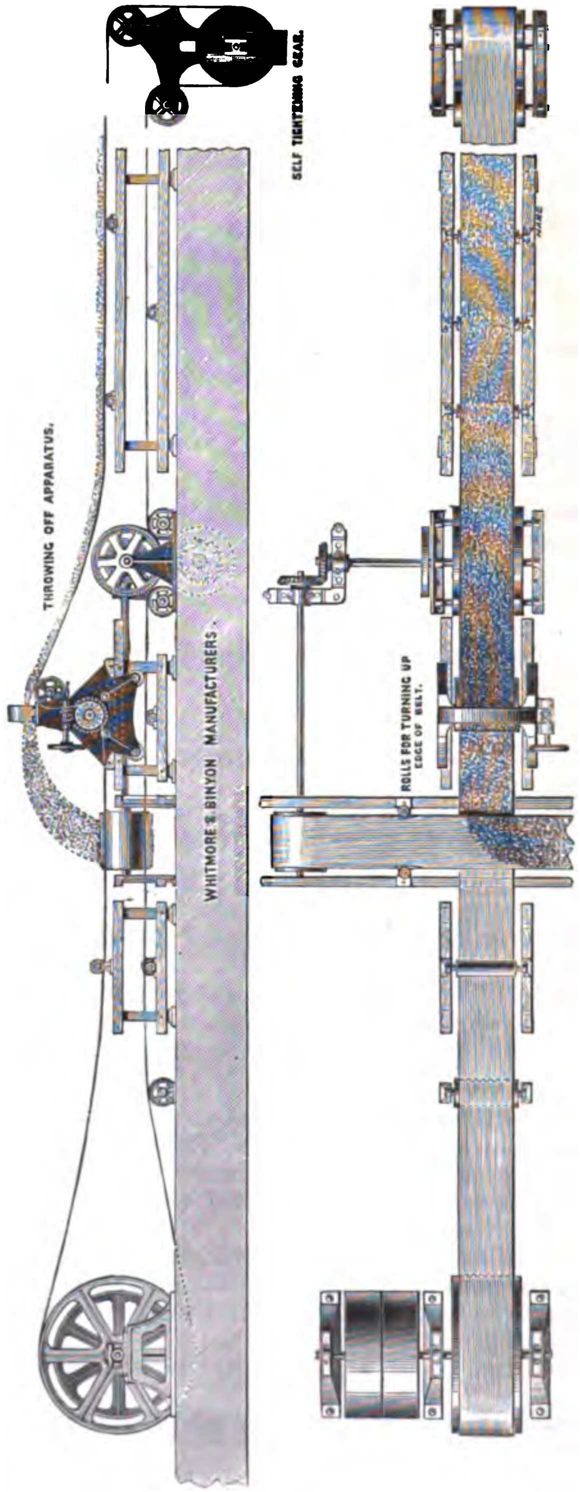

SELF TIGHTENING GEAR.
THROWING OFF APPARATUS.
WHITMORE & BINYON MANUFACTURERS.
ROLLS FOR TURNING UP EDGE OF BELT.

FIG. 70.—BELT-CONVEYOR, PLAN AND SECTION.

Conveyors that push forward the grain are represented by Figs. 71 to 73. Each of these plans is a modified mode of working the same principle.

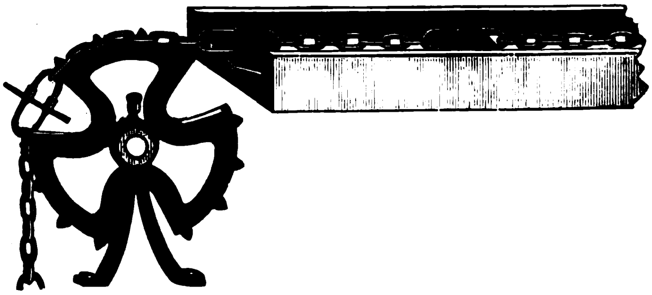


Fig. 71.—Harrison Conveyor.

The Harrison conveyor (Fig. 71) consists of a strong wrought-iron chain, to which, at suitable and regular intervals, push-plates are attached by a (patent) wrought-iron link. The trough is made so that the grain gravitates towards its deepest part, and the plates are shaped to fit it, so that every particle is removed. The plates and chain are propelled by a spoked and indented wheel attached to any shafting.

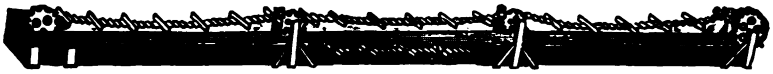


Fig. 72.—Link-Belt Conveyor.

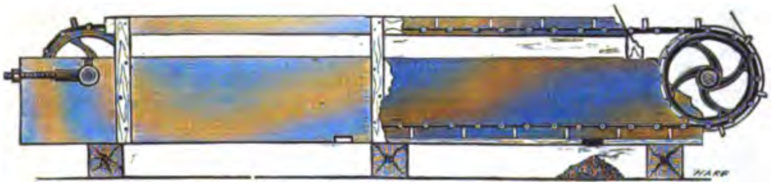


Fig. 73.—Mey's Conveyor.

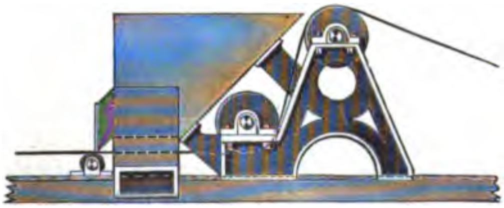


Fig. 74.—Belt-Hopper.

The link-belt (Fig. 72) is similar. The scrapers are attached to a link-belt of malleable iron links (Fig. 75).

All conveyors of this class are entirely self-cleaning, and they require less power than a screw.

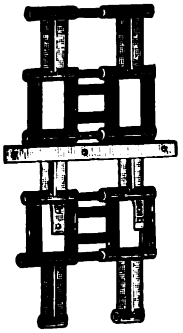


FIG. 75.—LINK-BELT-ELEVATOR.

Screw-conveyors are of two classes—continuous worm, or intermittent blade. (See Figs. 76, 77.)

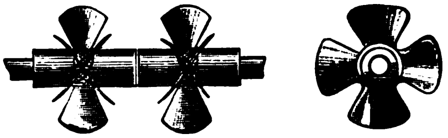


FIG. 77.—VAN GELDER'S INTERMITTENT SCREW-CONVEYOR.

For short distances and for dry malt these conveyors are effective, useful, and economical. They injure green malt, and, when of considerable length, absorb much power.

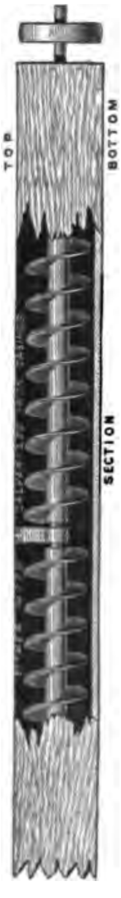


FIG. 76.—CONTINUOUS ARCHIMEDEAN SCREW-CONVEYOR.

COOLERS.

These are very important implements in modern maltings, as upon their effective capacity the entire success of the working depends.

The coke-tower invented by M. Galland very effectually accomplishes the cooling and moistening of the air driven through a malthouse. It consists of a tower or building of considerable height and size (see Fig. 52), filled with gas-coke, porous bricks, or other similar material, upon which a constant stream of water descends from a series of finely-perforated pipes. The air is driven or drawn through the saturated mass, and becomes sufficiently cold, even in the hottest weather, to control growing grain at a depth of upwards of 3 feet.

By this plan a considerable volume of water is constantly required.

A more efficient and simpler apparatus has been designed and patented by M. Saladin. This is known as an *échangeur*. This is a very ingenious application of the well-understood rapidity of evaporation of any liquid when spread out in very thin layers over large surfaces and exposed to a current of air. It consists of a cylinder, or series of cylinders, of increasing diameter, placed one within another. Each consists of finely-perforated sheet-iron. They are placed in a trough of water, just sufficiently immersed to ensure complete wetting. When rotated at a slow speed, the surfaces of all the cylinders are kept just moistened. A volume of air is either driven or drawn through, as may be required for any particular purpose. In the

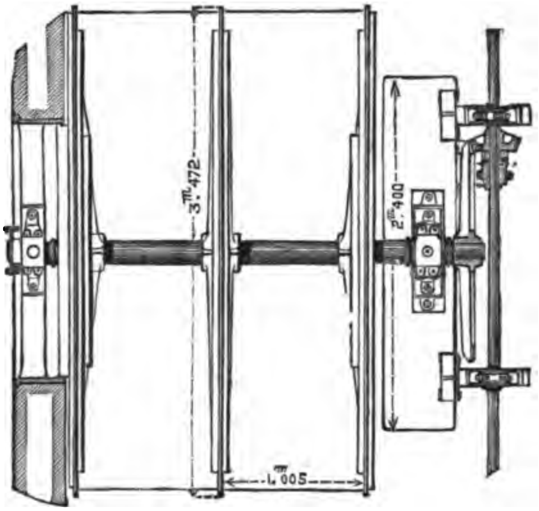


FIG. 78.—SALADIN'S ECHANGEUR, SECTIONAL PLAN.

model malting, as shown at Fig. 48, p. 230 (taken from that shown at work at the Brewers' Exhibition, London, 1883), the air was

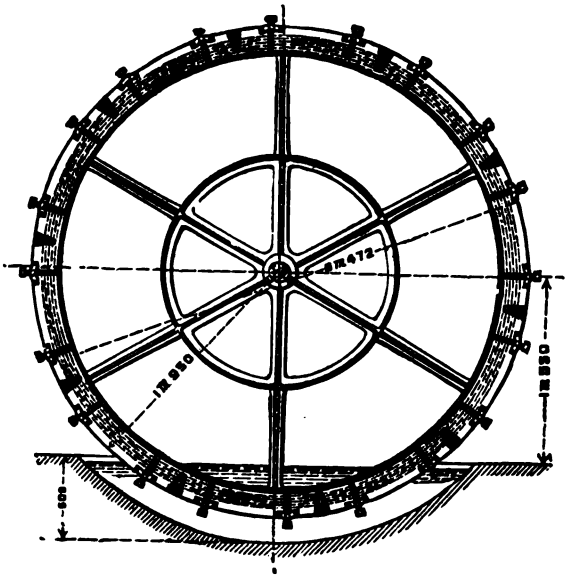


FIG. 79 .—SALADIN'S ECHANGEUR, TRANSVERSE SECTION.

driven through the *échangeur* and thence through the germinating barley. Here, or as employed in the malting illustrated,

p. 227—231, the air in its passage comes first into contact with the moistened cylinders, and if hot and dry it becomes moist and cool, for the constant evaporation upon the cylinders has a very considerable refrigerating effect.

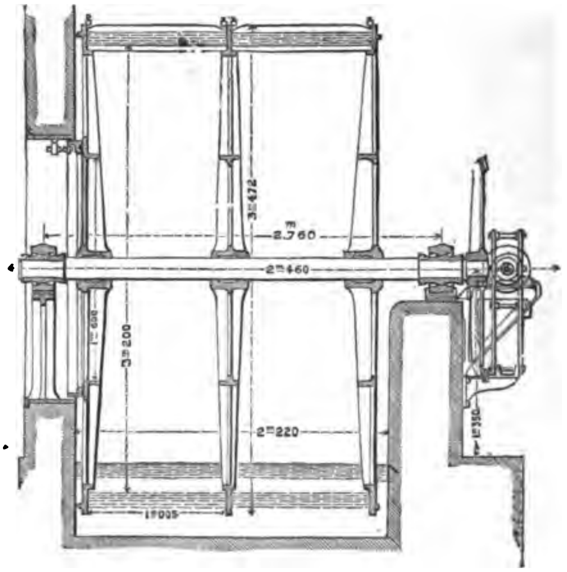


Fig. 80.—Saladin's Echangeur, Axial Section.

This was well known to the Egyptians over four thousand years ago. (See p. 233.)

The *échangeur* (as I explained before) is like a gigantic gargouleh, and by increasing the size and number of the cylinders, and causing the water in the moistening trough to circulate, any volume of air can be wetted to the saturation-limit corresponding to its temperature. It will be seen that this apparatus gives the maltster complete control of the humidity and heat, as well as volume, of the air driven through

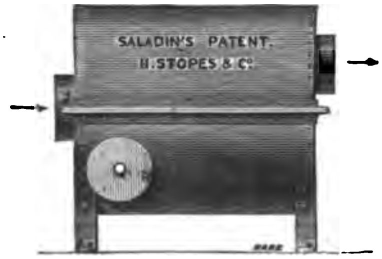


Fig. 81.—Saladin's Echangeur.

germinating corn, and proves an invaluable instrument in hot climes, or in Britain for pneumatic maltings.

Maltings in France of upwards of 530 quarters steep are kept at the right temperature by this apparatus, and numerous other large houses abroad and in Britain satisfactorily use it.

The power of this apparatus to cool air was tested at the International Health Exhibition, June 24th, 1884, when 10,000 cubic feet of air per hour was cooled by a small *échangeur*, 3 feet 4 inches in diameter, and 3 feet long, from 78° to 64°, the natural temperature of the water. The quantity of water used per day was seven gallons. The addition of eighteen pounds of ice to the water caused the temperature of the air to fall to 61° for upwards of one hour.

DISPERSERS.

Several forms of heat-dispersers are in use in kilns. The oldest type is still largely employed, and is simply an apron placed between the fire and drying floor. They are made of sheet-iron, woven-wire pugged with clay, or hair-mortar, tiles set in cement and covered with sand, &c., &c. (See p. 217.) Another disperser, also called a dissipator, is a cone of woven wire (Fig. 18, p. 199) placed immediately upon the tiles or wire of the drying floor. When used in a kiln with one floor, they serve to dissipate reek, but they waste fuel. In a double kiln they also serve to protect the holes in the upper floor through which the malt is dropped in loading the bottom floor. For this purpose a better form is a plain galvanised iron cylinder with hit-and-miss covers. (See Fig. 19, p. 199.) These give entire control over the ascending current of air, and by right use can regulate with much accuracy the relative temperatures of both floors.

ELEVATORS.

Corn is raised by numerous contrivances, and the forms of hoists and elevators are very varied. For general purposes it is convenient to use a band or belt running at any required angle over pulleys of from 12 to 30 in. diameter. To this belt a series of iron, tin, or copper cups is affixed at regular intervals of from 8 inches to 3 feet.

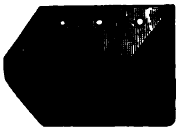


FIG. 82.

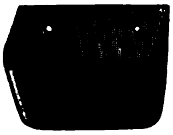


FIG. 83.

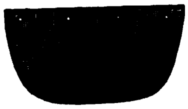


FIG. 84.

ELEVATOR CUPS.

The speed and capacity of cups, when lifting, regulate the quantity of corn raised. The nature of the corn rules the speed.

The cups vary much in shape and size. The forms in use in

America are probably the best. (See Figs. 82, 83 and 84.) Buckets are attached to belts with clips of tin or copper, bolts, and rivets. Should three rivets be needed in a large cup, they must be placed in a line and not bird-footed. The pulleys upon which the belt runs require to have suitable dimensions. For many purposes the best belt is a continuous malleable iron chain running upon toothed wheels and guides. (See Figs. 85, 86 & 87.)

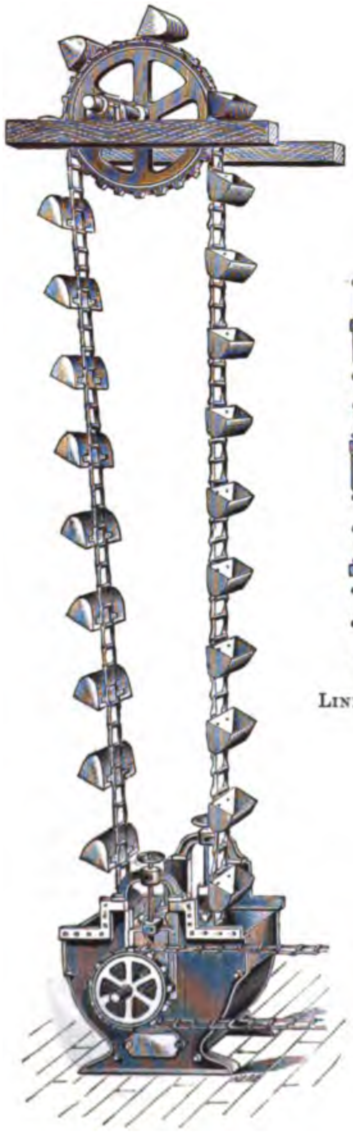


FIG. 85.
IRON LINK-ELEVATOR.

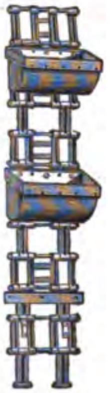


FIG. 86.
LINK-ELEVATOR.

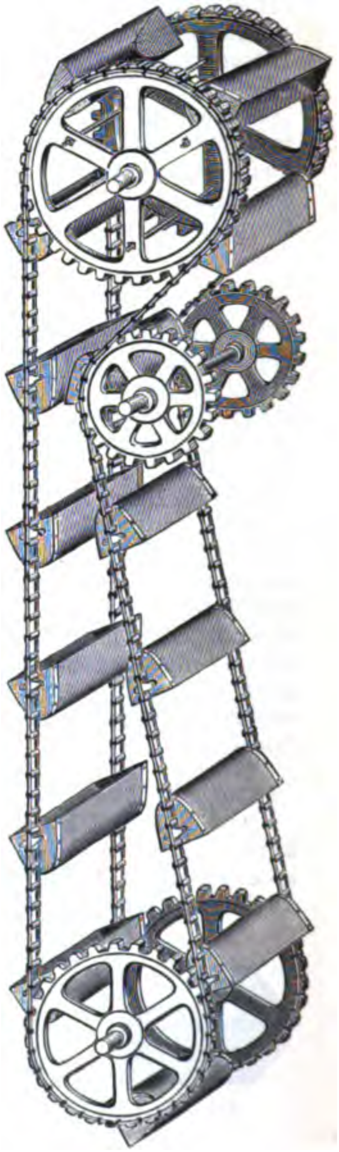


FIG. 87.
LINK-ELEVATOR.

By this method the slip of belts is avoided, and there need be no tension, with, consequently, very slight stretching. Belts of this class can be used for wet, or very hot corn. They can even be run in water, and stand exposure of any kind in kilns or other positions.

Very numerous forms of hoisting gear are now in use driven by bands, ropes, wires and frictional cones. Of these probably the best are the simpler forms, such as Figs. 88, 89 and 90.

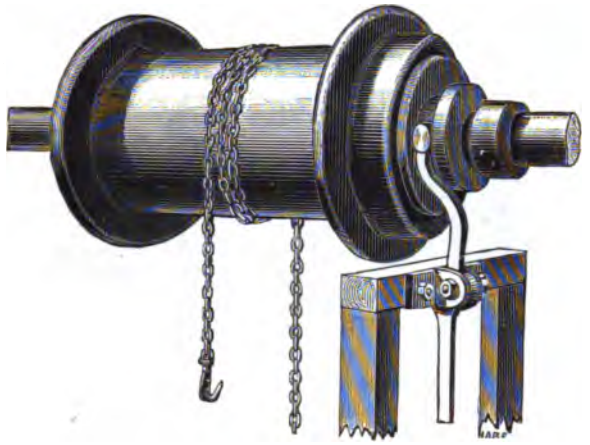


Fig. 88.—Friction Hoist.

Fig. 88 is one or more barrel-drums loosely fitted between collars, and a frictional clutch as shown, which with a simple lever can be made to grip the barrel tightly and raise sacks, &c., to any floor, and can also lower any ordinary weight as desired. In addition to this mode of raising barley to the loft, it is always desirable to have a small receiving-hopper placed on the ground-floor, into which the barley can be weighed immediately it is received from the waggon or truck; and, passing through a criddle screen, it can fall into a vertical elevator (already

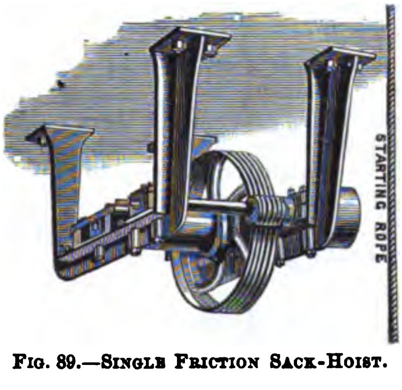


Fig. 89.—Single Friction Sack-Hoist.

described) consisting of buckets attached to a chain or belt, in the ordinary way. The head of the elevator is usually at the top of the building, and so arranged that the barley can be at once discharged into the screen and sorters, or into bins.

Figs. 89 and 90 illustrate a different form of friction-hoist, which for many purposes is more reliable both for lifting and sustaining the weight when raised. All hoists of this class are provided with brakes which minimise the risks inseparable from rapid raising of corn in sacks.

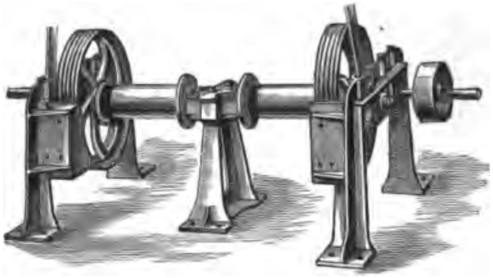


FIG. 90.—DOUBLE FRICTION SACK-HOIST.

These hoists can be easily fixed by being bolted to ceilings, walls, or upon floors. The chain and rope are carried over a cathead pulley, or by other means, to the required position.

A very safe arrangement is shown by Fig. 91, which is a convenient method for a malting. It takes up little space, and can be so arranged that the working is controlled by one rope, by which sacks may be raised and lowered at differing speeds, or left suspended at will.

In some maltings it is desirable to have lifts erected. In these cases a direct acting hoist similar to those made by Messrs. Waygood & Co. is found to work satisfactorily. They are driven by a separate gas- or steam-engine as illustrated (Fig. 92), or they can be worked from any line of existing shafting which conveys sufficient power. All such lifts require care in working, and are best when duly counter-poised, and fitted with automatic safety-brake-gear.

ENGINES.

Three forms of engines are used by maltsters—water, steam, and gas.

Water-engines are either undershot or overshot water-wheels, turbines, or engines driven by water at considerable pressure acting upon a piston, so far similarly to steam as the differences in elasticity and bulk admit.

Comparatively few maltings are constructed with the object of utilising the flow of streams or tides, although in many cases an excess of power exists, and could be inexpensively adopted.

Steam-engines have one distinct advantage over water or

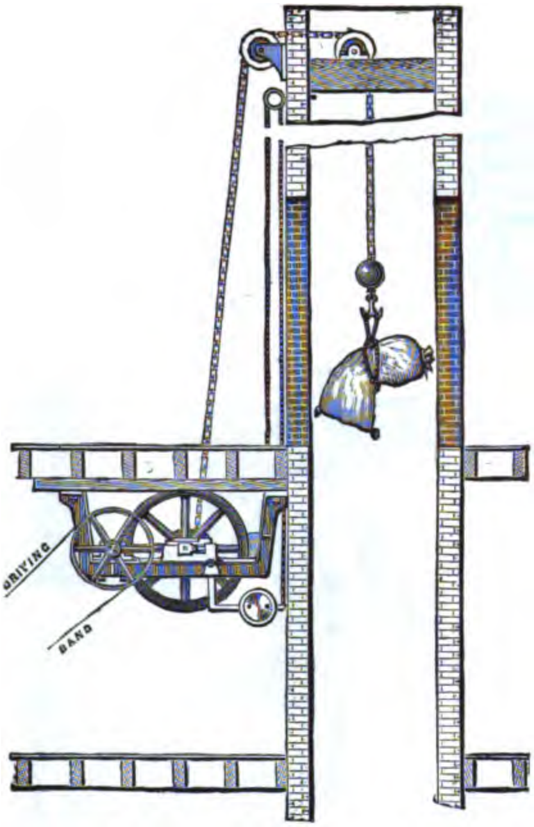


Fig. 91.—Power-Hoist and Sack-Tackle.

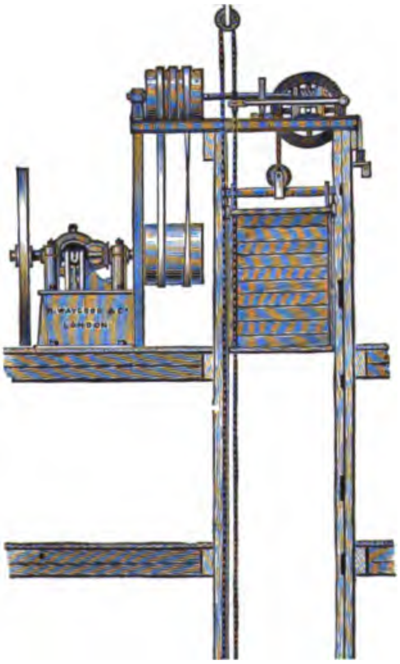


Fig. 92.—Warehouse-Lift.

gas-motors, in the facility they offer for the regulation of temperature of steep-liquor.

Any ordinary type of boiler or engine will act efficiently in a malt-house. Very little power is required, excepting for pneumatic houses, and engines are kept running for a few hours per day only. Probably the best type yet invented is the ordinary horizontal-engine, of which very many varieties exist.

Commonly the mistake is made of fixing a boiler of very small power for the work to be done. Consequently very constant attention has to be given to it.

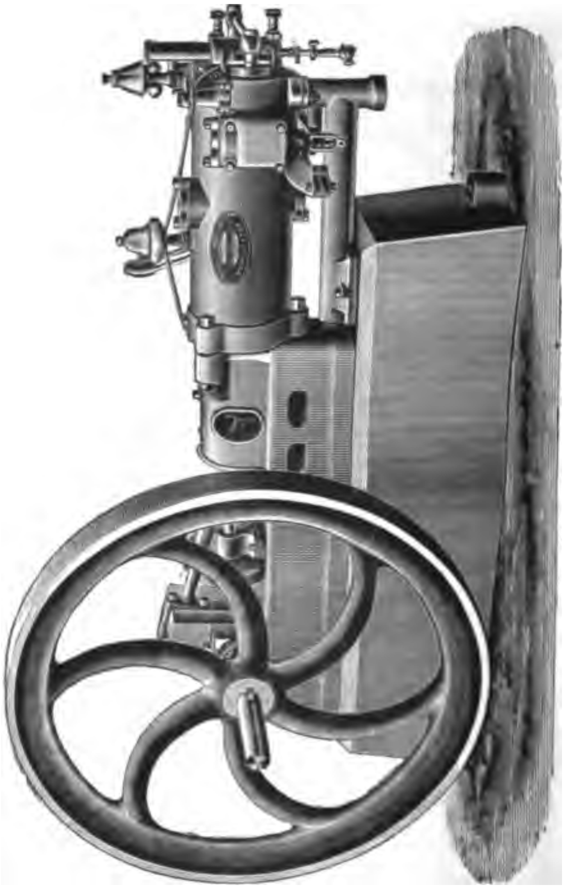


Fig. 93.—Eight or Twelve H.P. Otto Gas Engine.

Gas-engines are much appreciated by maltsters generally, for the small amount of attendance they require, and their capability of almost instant use at any time.

The form at present most liked, is known as the Otto engine, Fig. 93, patented by Crossley Bros., Ltd., Manchester.

It is made with self-starting arrangements, and is in many positions very economical and useful.

FANS.

Fans are employed by maltsters for three purposes, viz., to clean corn, increase draught in kilns, and drive air through floors.

Any good form of fan, that will do these operations efficiently, can be used. (See Fig. 29.)

FILTERS.

Until very recently, no attention has been paid to the purification or modification of the water used in steeping. The importance of the subject has finally been recognised, and filters are now, occasionally, found in use.

A large number of filters exist of widely different character and form. Some of these are applicable to maltings, and their suitability is ruled by the nature of the work they have to perform.

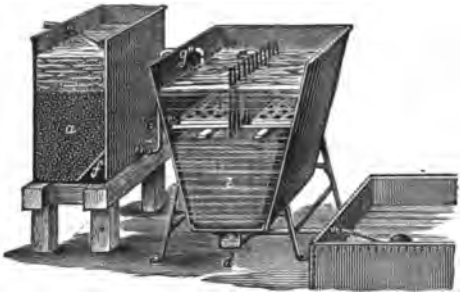


FIG. 94.—FILTRE RAPIDE.

One of the most generally useful forms is the Filtre Rapide, patented by Mr. P. A. Maignen (illustrated by Fig. 94).

FIRE-IRONS.

No malt-house can work without a fire, therefore fire-irons are used in every case. These are generally of the simplest character possible, and consist of shovels for coal, forks for coke, stirrers or clinker-bars, hoes, and pokers.

FORCING-TRAY.

This invaluable instrument consists of a series of trays or shallow copper troughs with double bottoms, capable of holding water. These are kept at any given temperature by gas, steam, or any other reliable and easily-regulated source of heat. Upon them is placed any suitable arrangement of bottles, jars, or beakers to accomplish the particular end desired. For testing malts, either for extract or stability, they are of very great utility, and the whole industry is greatly indebted to Mr. Gillman and Mr. Horace Brown for initiating their use.

Forks.—See Turners.

Gauging-Rods.

During the collection of the Malt-tax, one of the most important and universal tools was a good and accurate gauging-rod. Cistern, couch, floors, and kiln were all measured at frequent intervals. With the present freedom of working, gauging-rods are not necessary, and, excepting to measure the quantity of corn steeped, they are no longer used.

Gelatinisers.

These implements are used only by the makers of the various forms of patented malts known as gelatinised and other grain. Commonly they are cylindrical vessels of iron made to rotate upon an axis, and fitted with a revolving shaft or stirrer. They are constructed to stand considerable pressure of steam, and are fitted with all necessary supply- and discharge- steam-valves or cocks, and also have large receiving and discharging grain valves.

Graders.—See Screens.

Hoists.—See Elevators.

Hose.

Maltings are occasionally fitted with fire hydrants and hoses. These are of any approved type, and may be of canvas, leather, or indiarubber. They are, when fixed, also used for washing down floors, and for this purpose are of great value.

Very large houses have a small hose on each floor, or a series of small hoses attached to a separate main, fitted with an accurate meter for the purpose of sprinkling. Two or three ply flexible hose, 1¼ or 1½in. diameter is used for this purpose, and the nozzle-piece should be of copper, very finely perforated.

Hummellers.

Commonly barley has the awns sufficiently removed by the hummelling drum of the threshing machine. Occasionally this is not the case, when it becomes necessary for the maltster to hummel the corn prior to steeping.

A hand hummeller (also called haveller) made by Mr. Boby, Bury, is illustrated (see Fig. 95).

This machine is very simple, and can easily be worked by one man. The barrel is made of iron, and a strong wrought iron spindle runs through the centre, on which is fixed a series of knives which revolve at great speed. These knives are so shaped that, although the barrel is fixed perfectly straight on the frame, they force the barley along the tube, so that it is impossible for the corn to escape from the spout until it has been subjected to the action of the whole of the knives in the barrel, and by the time the corn reaches the outlet it is found to have been effectually deprived of the awns. One man can hummel sixty bushels per hour. Price, £5.

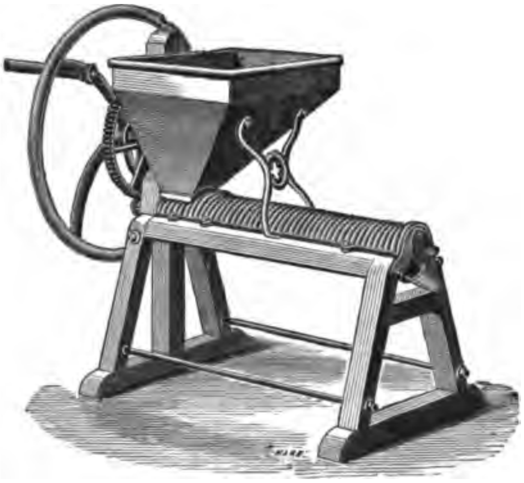


FIG. 95.—BOBY'S PATENT BARLEY- AND MALT-HUMMELLER.

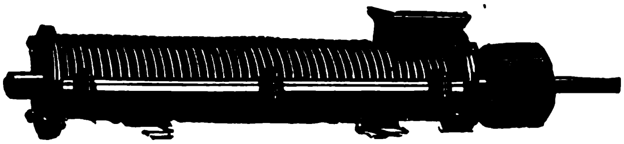


FIG. 96.—BOBY'S IMPROVED BARLEY-HUMMELLER FOR POWER.

Another machine for steam-power will hummel fifteen to twenty qrs. per hour. (See Fig. 96.)

This machine costs about £10.

HYGROMETER OR PSYCHROMETER.

Although a maltster's operations are nearly all most directly affected by the relative dryness or humidity of the air, very few attempts are made to ascertain the degree. Watery vapour is always and everywhere present in the atmosphere, and its state is a matter of the greatest importance in the economy of nature. The proportion of aqueous vapour in the air is subject to constant and wide variation, and several forms of instruments have been devised to measure it, the use of most of which is comparatively simple.

If the vapour be at its greatest possible density for the temperature, the least reduction will cause deposition. The air is said in such cases to be saturated, a term which, though technically incorrect, is convenient for general use.

If, as is generally the case, the air is not saturated, it is desirable to learn how far it is charged with moisture, and this is effected by ascertaining the degree of depression of temperature requisite to bring about condensation.

The principle of the hygrometer consists of two thermometers, one of which registers the temperature of the air, whilst the other is artificially lowered in temperature till dew forms upon its surface. The difference of temperatures being noted, the humidity of the air is found by tables.

In one form of hygrometer (Figs. 97 and 98), the wet bulb is surrounded with muslin, kept wet by capillary diffusion by a cotton thread communicating with a vessel of water. Evaporation keeps this thermometer at the degree corresponding with the dew point, whilst the other records the actual temperature. The evaporation from the wet muslin depends upon the proportion of watery vapour already present in the air.

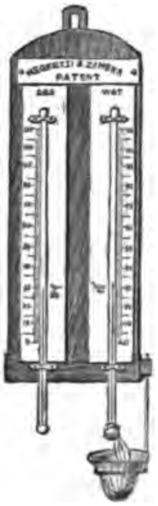


FIG. 97.—HYGROMETER.

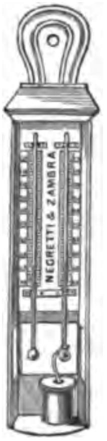


FIG. 98.—HYGROMETER.

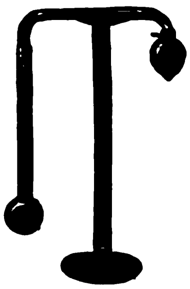


FIG. 99.—DANIELL HYGROMETER.

A more elegant form of instrument is the Daniell hygrometer, designed by that eminent physicist in 1820. It consists of a bent glass tube with two bulbs (Fig. 99). The bulb of the longer limb is half filled with ether, the rest of the tube being a vacuum; this bulb is of black glass, whilst the other is covered with muslin.

Ether is dropped upon the latter till its evaporation so lowers the temperature that the black bulb becomes covered with dew, the temperature of which is given by the delicate thermometer within the tube. The thermometer on the stem gives the actual temperature.

Jones' hygrometer is a little simpler, having but one thermometer. The temperature being first read off, the black silk covering the sides of the bulb is wetted with ether till condensation takes place on the flat black glass top of the bulb, when the temperature is again read.

Regnault's condensing hygrometers are more elaborate, requiring the air to be drawn through them by aspirators.

ICE-MACHINES.

Excepting in very large pneumatic maltings, the use of ice-machines is unknown. As these machines are so rarely used, and are of a complex character capable of much improvement, no description of them is desirable here.

The production of ice for general use is an industry which could be profitably carried on by maltsters.

LUBRICATORS.

Very numerous forms of lubricators are in general use. By far the best, however, for maltsters is Stauffer's patent.

This has a special lubricant, which never freezes, gums, or clogs, and as it can be forced a considerable distance along a tube, it allows the cap to be put in any convenient or readily accessible position a considerable distance away from, or even below the wearing part, and it can be put at the side and bottom of bearing as well as the top.

CHAPTER XVII.

TOOLS AND APPARATUS (*continued*).

Tools and Apparatus—
Malt Crushers. Measures. Microscopes. Mills. Pattens. Ploughs. Psychrometers. Pumps. Purifiers. Regulators. Roasters. Sacks. Samplers. Screens. Shovels. Slippers. Spargers. Steam-boilers. Stencil-plates. Testers. Thermometers. Tiers. Treaders. Turners. Valves. Washers. Weighing-machines.

MALT-CRUSHERS.

SMALL malt-crushers are very generally used to determine the colour and friability of any required sample. They are as Fig. 100. The prices are—

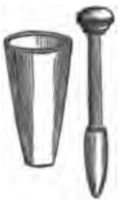


FIG. 100.
MALT-CRUSHER

		s.	d.
Malt-crushers, Cocus wood	... ...	2	0
,, Ivory	... ...	12	6

MEASURES.

Measures are used to record the quantities of barley received and malt made. They range from the quarter or eight bushels to a quarter pint, thus :—

1 quarter	= 10·21	cubic feet,	8 bushels,	32 pecks,	64 gallons,	512 pints.
1 bushel	=2218·19	cubic in.	1 ,,	4 ,,	8 ,,	64 ,,
1 peck	= 554·54	,,	-- ,,	1 ,,	2 ,,	16 ,,
1 gallon	= 277·2738	,,	— ,,	— ,,	1 ,,	8 ,,
1 pint	= 34·65923	,,	— ,,	— ,,	— ,,	1 ,,

Of these measures the bushel is the one actually used in the malthouse. The dimensions and shapes of the Imperial bushel vary, although by law one particular type only should be used for corn. (See Figs. 101 and 102.)

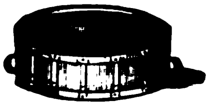


FIG. 101.—METER'S BUSHEL.

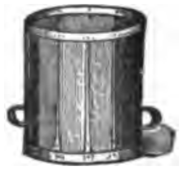


FIG. 102.—STRIKE OR DRUM-BUSHEL.

Measures of varying names and capacities still continue to be used in Britain, such as quart, quartern, windle, stone, sack, comb, bag, cental, load, strike.

Several of these have varied quantities within comparatively limited areas, and are rapidly becoming obsolete. Nothing but the most ridiculous and shameful prejudice aids their retention. The universal acceptance of a metrical system of weights, measures, and coinage, would be of enormous saving and gain to every practical and honest man.

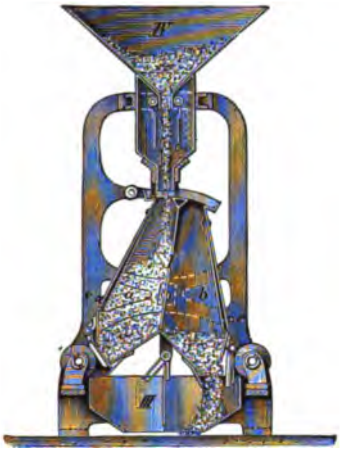


FIG. 103.—WITT'S PATENT MEASURER.

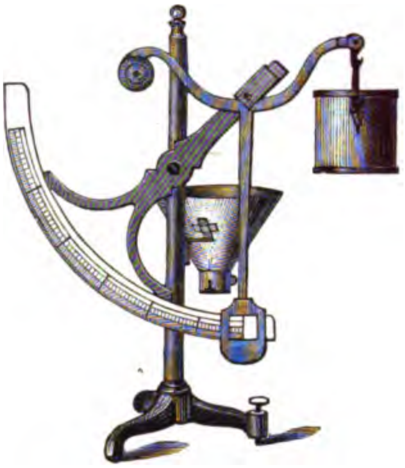


FIG. 104.—CHONDROMETER.

Malt is frequently measured by automatic machines which mechanically register the weight or measure of the corn passing over them.

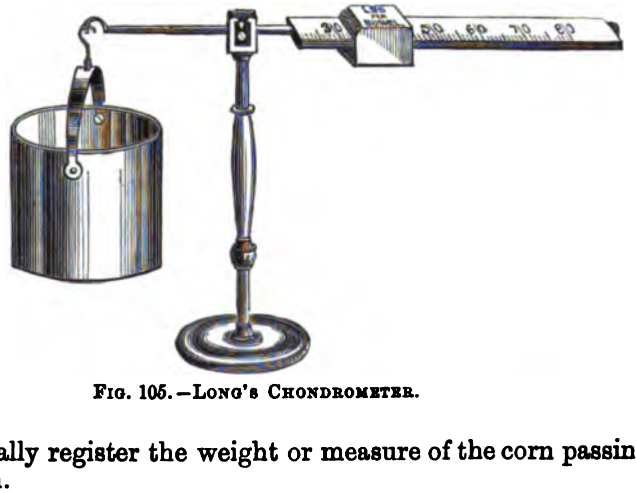


FIG. 105.—LONG'S CHONDROMETER.

Of these Witt's patent is reliable and effective. (See Fig. 103.) It records in bushels and quarters any description of corn or seed passing through it.

Chondrometers are of considerable value in testing accurately and quickly the weight of any corn from a small sample.

Several forms are made. The simplest is that illustrated, Fig. 104.

The instrument is provided with a proper filling-funnel and strike, consequently the various grains fall into the receiving measure with uniform density. It is therefore sufficiently accurate and reliable for practical and ordinary use. The indication afforded is clear and simple. Cost 25s. to £5. Numerous other chondrometers are in use, the majority having a small measure at the end of a lever or beam by means of which the weight of half a pint furnishes a criterion of the total weight of a bushel or quarter. Of these Long's (Fig. 105) is very generally approved.

Microscopes.

A very necessary instrument for maltsters who care about their business is a magnifying lens of some kind. Numberless kinds of hand- and eye-glasses are made, but very little used. A great variety of good microscopes also areoffered to maltsters, and their use is becoming somewhat general.

The best form of microscope for general practical work is a binocular of good definition. Very numerous makers of these instruments supply them in great diversity of form at a moderate price.

Mills.

Malt, prior to use for any purpose (excepting some forms of cattle feeding), is ground or crushed. Owing to its natural friability, very simple mills are capable of satisfactorily grinding malt for brewing and distilling purposes. The essential features are that the mill shall be simple, durable, and easy of adjustment. The rolls require to be of hard non-porous iron or of steel, with long bearings and spindles of large diameter.

The front roll is generally set up with adjustable worm- and wheel-motion, which moves each end of the roll with uniformity, and the mills are complete upon strong cast-iron foundation-bed, so that they can be set up in any position or upon any floor or bearers.

The usual prices of mills of this class are:—

Size of Rolls.		Prices of Mill.
Diameter.	Length.	
6 inches.	1 ft. 0 in.	£12 10s. 0d.
12 „	2 ft. 6 in.	£40 0s. 0d.
16 „	2 ft. 6 in.	£60 0s. 0d.
18 „	3 ft. 0 in.	£80 0s. 0d.

For some classes of malt, particularly gelatinised and other highly-dried steely grain, another form of mill is essential.

One of the best at present known for this work, is the Perfect Mill. (Fig. 107.)

This mill, if grinding malt, rice, barley, and even maize, strips

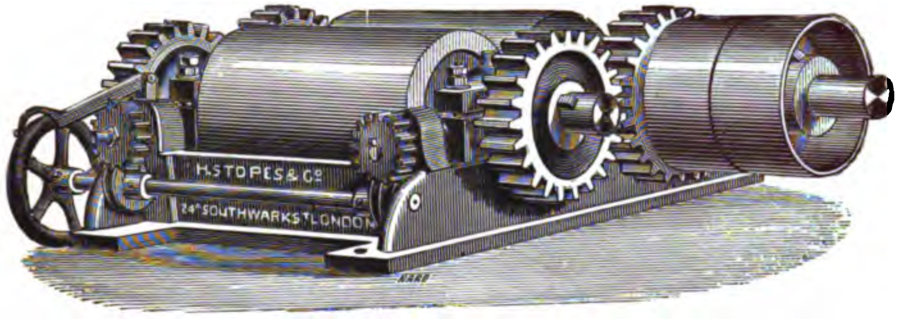


FIG. 106.—MALT-ROLLS.

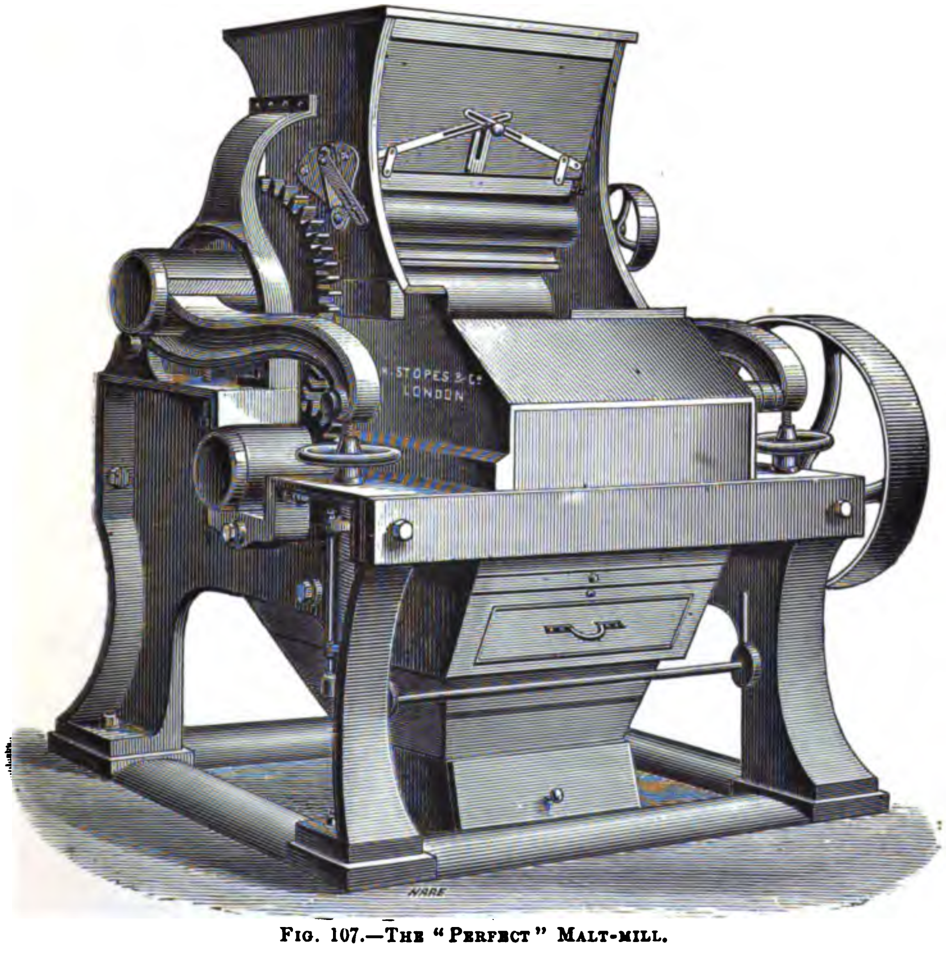


FIG. 107.—THE "PERFECT" MALT-MILL.

the husk completely away, and leaves the starchy portion of the grain evenly granulated with a very low percentage of flour.

Each mill is fitted with two rolls of non-porous chilled iron turned upon massive steel spindles. The rolls are fluted, with grooves running spirally, and are of unequal size, one being 20 inches in diameter and the other only 8 inches. The small roll is also driven more slowly, so that the differential speed is great, 8 to 1.

The bearings of gun-metal are of an excellent design, being very long and open at top to receive tallow or other firm grease, they therefore never heat, and are very durable.

The rolls can be set to any point, and left with safety to unskilled attendance, for, by their construction, they can be thrown wide apart, and returned to position any number of times with no interference with the set. The feed can also be stopped and started without alteration to the regulating slides. By these means absolute uniformity of grist is ensured.

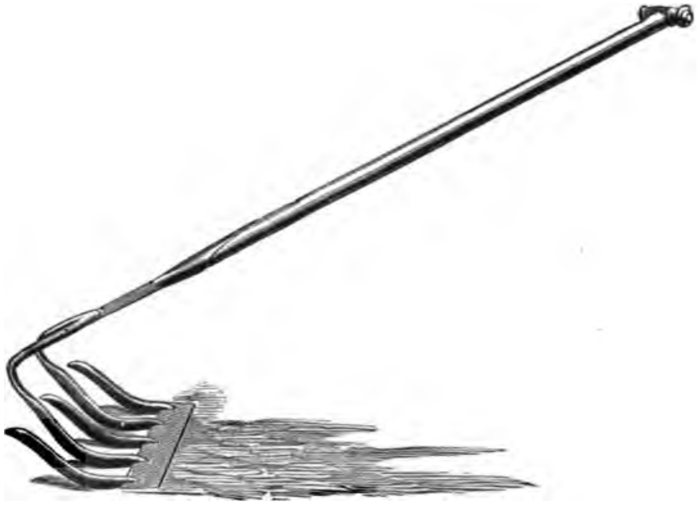


Fig. 108.—Plough.

The following are the dimensions and price:—

Length.	Breadth.	Height.	Rolls.		Price.
			Diam.	Length.	
4 ft. 9 in.	2 ft. 10 in.	4 ft. 2 in.	20 in.	20 in.	£85
			8 ,,		

Very many other forms of mill exist, and numerous methods of grinding are adopted, ranging from small mills with a wide-rimmed fly-wheel driving a small crushing roll by friction, to elaborate and ponderous mills having four steel rolls variously arranged.

Ploughs.

Several forms of malt-ploughs are known and used. One of the best is as represented by Fig. 108.

The bottom, of iron, is commonly made sufficiently heavy to keep to the bottom of the floor when it is being turned. The handle is best of wood. Prices 20s. to 30s.

Another kind is made, and is a simple piece of wood, of wedge-form, securely screwed, at an angle of 40°, to a handle. The lower edge is thin, and about 4 to 6 inches wide. This form of plough should be used in all cases where the floor is uneven, rough or full of cracks.

An improved form of plough has been invented by Mr. Flinn, so constructed that, in passing through the malt, it distributes a volume of cold air. This is forced through a fan and échangeur, and conveyed by a light flexible indiarubber hose.

PSYCHROMETER.—See Hygrometers.

PUMPS.

The forms and descriptions of pumps used in maltings are very varied and numerous. They embrace direct-acting steam- and air-pumps; single-, double-, and treble- barrel-lift, and force-pumps, centrifugals, rotary, &c., &c.

The type of pump best adapted to certain work is necessarily ruled by the nature of that work, and as it varies in nearly every malthouse, the particular sort of pump used has to be determined accordingly.

PURIFIERS.

Only very recently have purifiers been employed in maltings. Their uses are varied and numerous.

It is now proved to be beneficial to purify all the material and elements controlled by the maltster. Thus air, water, grain and premises are alike benefited by purification.

The air supplied to pneumatic malthouses is purified by drawing or forcing it through cotton-wool prior to its being cooled and moistened. (See "Coolers.") This material arrests very numerous germs and spores of low organisms and other impurities, all of which are best kept from direct contact with germinating grain.

Water is purified in a variety of ways. (See "Filters.")

Grain is also cleaned very variously. (See "Screens.")

Maltings generally are purified in a small diversity of ways.

Cisterns of iron are painted with hot lime, and rinsed sometimes with bisulphite of lime. Brick and cement cisterns are also lime-whited cold, and similarly washed with calcic bisulphite.

Growing-floors are washed and scrubbed, but rarely treated with bisulphite of lime.

Kilns, malt- and barley-bins, and walls generally, are also well brushed and frequently limewhited. The underside of kiln roofs are also in many cases varnished, painted, or treated with Stockholm tar, applied hot.

In a malt-house, as in a brewery, cleanliness of the strictest character is of great direct value.

REGULATORS.—See also Dispersers.

Numerous inventions are made and worked to regulate with accuracy and automatically, if possible, the heat of air in kilns.

One of the most effectual self-acting heat-regulators is King's (Fig. 109). This has been fixed to many kilns, and is found to act with very good results, if intelligently looked after.

It consists of a large wheel of hollow steel, partly filled with mercury and fusel oil, alcohol, or, according to the heats required in kilns, ether. This wheel is attached to a spindle, which is free to revolve easily. This has a grooved wheel upon it, from which a wire-rope conveys any movement it may make to a corresponding wheel attached to a large diaphragm of sheet-iron fixed in any convenient position over the furnace. Any accession of heat causes a displacement of the mercury, and consequent movement of the wheels and door. As the amount of this movement is under control by a series of weights also suspended from the spindle carrying the driving wheel, it follows that any required degree of temperature can be maintained in the heat chamber of the kiln. The volume of cold air that may enter, causes a reduction of temperature and backward movement of the door.

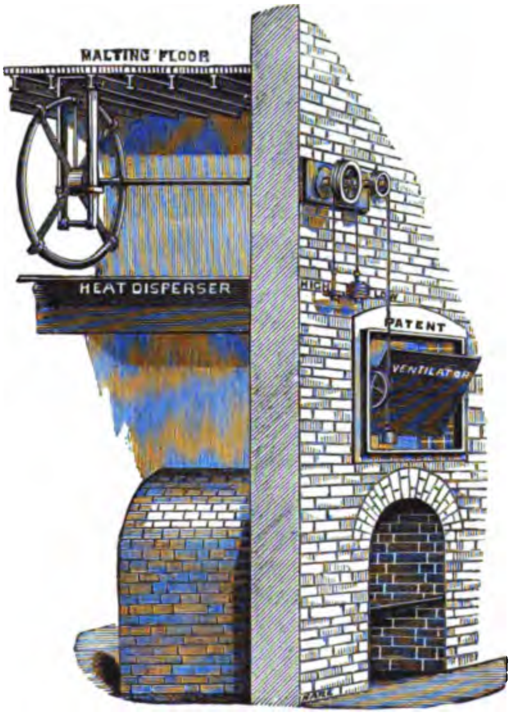


FIG. 109.—KING'S HEAT-REGULATOR.

When correctly working, this plan is manifestly better than any ordinary arrangement of sliding or swinging doors, or other air-inlets.

Numerous kilns have ordinary iron or wooden slides covering or attached to corresponding openings over or beside the fire-places. These are regulated by the kiln-man when attending the fires.

ROASTERS.

The monopoly of malt-roasting, created by the numerous stringent Acts of Parliament that dictated every act of roasting malt, having been abolished by the repeal of the Malt-tax, many maltsters and brewers now manufacture black, patent, and other coloured malts.

Any lengthened cylinder rightly arranged to rotate over a fire or gas-jets can roast malt. On a large scale, these cylinders contain three to four bushels at a charge. Many maltsters, however, use a smaller portable machine, containing a cylinder capable of roasting one or two bushels. This is a simple fire-place (see Fig. 7) enclosed with sheet-iron, fitted with a chimney to convey away steam, smoke, and fumes. In it is a small sheet-iron cylinder, freely perforated, holding one or two bushels of corn, and placed a short distance above the grate, on bearings that permit it to be freely turned. The corn is put into this cylinder, and is kept constantly but slowly turned over a slow coke fire. As the steam passes off, the fire brightens and the heat increases. In thirty minutes all the steam has passed away, and a fine rich aroma begins to steal from the malt. This increases quickly, and in five minutes it is necessary to inspect the malt. If the process has been rightly managed, a good chocolate-tinge has been acquired, which quickly deepens, and in forty minutes, in all, the operation of roasting is complete. The malt is turned out to cool and mellow, and a second charge can be at once placed in the cylinder, and the operation repeated.

A very short experience is sufficient to give a considerable degree of skill to any workman, so that malt of a uniform colour is produced, and few manufacturing processes are more simple.

The cost of a portable roaster of this type is £10 to £15, capable of roasting one or two bushels each charge, and from £40 to £100 for the larger fixed machines, which roast three to eight bushels. The larger machines are driven by power.

A gas malt-roaster, known as Andrew's patent (Fig. 110), is also used. This apparatus consists of a steel cylinder mounted on an axis furnished with driving-pulleys. It is partly surrounded by a cylindrical iron casing lined with fire-clay, to prevent radiation of heat, and is heated by means of a gas-burner arranged along the entire length of the revolving cylinder. To this, gas- and air-supply pipes are attached, and the air is supplied to the burner under pressure by means of an air-pump, which creates a blast of air and gas at the burner, and much intensifies the heat, thus expediting the roasting, and economising gas. The malt is put in a hopper at the top, from which it runs into the cylinder, and is emptied, when finished, through a slide into the cooling-tray. The cylinder is provided with an internal arrangement, which causes the malt to travel from end to end as it rotates, thus ensuring evenness of roasting. It is fitted with a tester for examination during roasting without stopping the machine, and a special arrangement for carrying off the smoke and heat from the room in which the roasting is carried on, as the fumes are very overpowering. The size usually made roasts six bushels at a time, taking from forty-five minutes to one and a half hours, according to the dryness of the malt and the height of colour required. The consumption of gas ranges from 40 to 60 feet per bushel, depending upon the condition of the malt prior to roasting and the degree of colour given it.

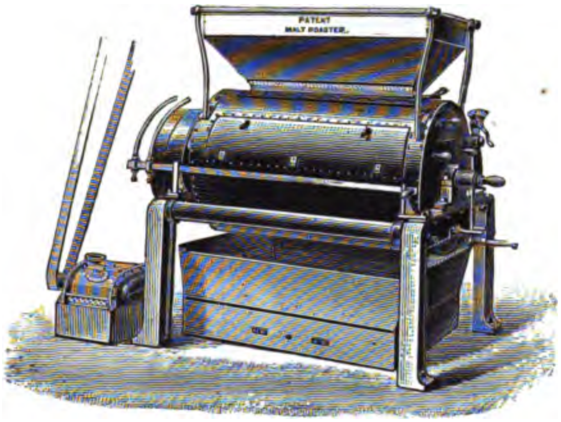


Fig. 110.—Waygood's Roaster.

Sacks.

Malt- and barley-sacks usually hold one comb or four bushels. They are commonly made of jute, and it is considered best to have them of good closely-woven texture "to keep out air." Their use is, however, much to be condemned for malt, excepting for very temporary purposes of removal from the malting to other places. Storage of malt in sacks is an absurdity.

The use of sacks necessitates also tiers, which are, customarily, lengths of rope-yarn, or old rope-strands untwisted, about 10 to 14 inches long. When malt is consigned by rail, it is also usual to secure the two ends of a tier with a leaden pellet or label, stamped with the owner's name, which makes it impossible for the sack to be opened, and any of the malt removed, without detection.

Sacks are also almost invariably branded or painted with the owner's name.

The use of sacks in a malthouse therefore involves the employment of tiers, stencil-plates, and brushes or branding machines, and pellet-pressers or stamps.

SACK-HOLDER.

This machine is used in small maltings, where one man may be working without companions. The illustration, Fig. 111, sufficiently explains it.

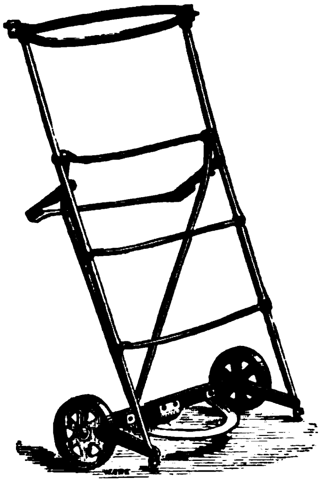


FIG. 111.—SACK-HOLDER.

SAMPLERS.

A sample of grain from a large bulk is frequently taken by means of a sampler. This is a small brass instrument attached to the end of a long rod or handle (see Fig. 112), which permits the grain to enter the receiver at any required point, and upon its withdrawal the closing of the valve securely retains it. It is also used for trying the heat in large heaps, and so saves the time and trouble of turning them over. Price, with handle 6 ft. long, 10s. 6d.; 8 ft. long, 12s. 6d.

FIG. 112.—SAMPLER.

Samples are placed in tins, small bags of calico or linen, and bottles. Bags are more commonly used by farmers for barley. Envelopes of glazed paper or linen are chiefly used by merchants, and tins or bottles by maltsters and factors for malt.

It is comparatively rare for a sample of either barley or malt to exceed one pint.

A small sampling-screen is now frequently found in good offices. This is a small screen, fitted into a neat French-polished wooden box, about 14 in. by 9 in., and is very useful for testing the quality of samples of barley or malt that may be offered. The sample has merely to be emptied into the box, and by simply giving the screen a backward and forward motion, all the thin corns pass through into a drawer underneath, leaving the best at the top, which can be easily emptied out. This is a convenient mode of determining the percentage of small corns contained in a given sample. The price is £1.

SCREENS.

The number of screens used by maltsters is very great. They are used for a diversity of purposes, as follows:—

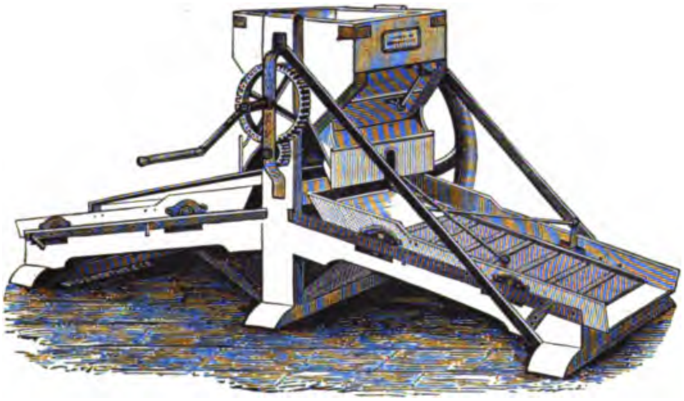


FIG. 113.—BOBY SCREEN.

Barley-screens to separate from barley all other matter, and divide it into varied grades.

Malt-screens for separation of all combes and other matters, and also for grading.

The simplest form of screen is one which merely separates the small or tail-corn from the big corn. Several makers of screens for this purpose have very good machines. Figs. 113, 114, illustrate one of the best known, which is very generally used, and is called the Boby screen. This machine is now made in a form that, by suspending the screening surface upon wood springs, the principal and most costly wearing parts are replaced, and the power required to turn them is reduced to a minimum.

Any number of wire beds, of different gauges, can be furnished with the same machine, which are so arranged that they can be removed and replaced with the same facility with which riddles are changed in a dressing machine.

A fuller and more developed form of this machine has attached to it a blower, as in Fig. 115.

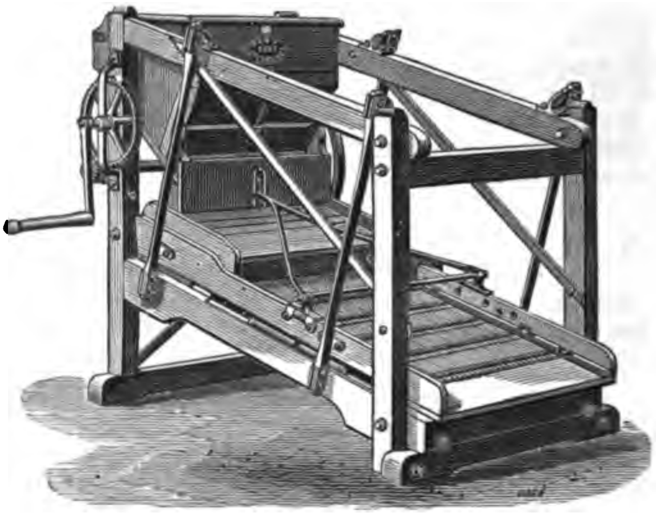


FIG. 114.—BOBY SCREEN WITHOUT BLOWER.

This accordingly removes the dust and very light corn. A very similar type of machine is Coleman & Morton's patent step-screen. (See Fig. 116.)

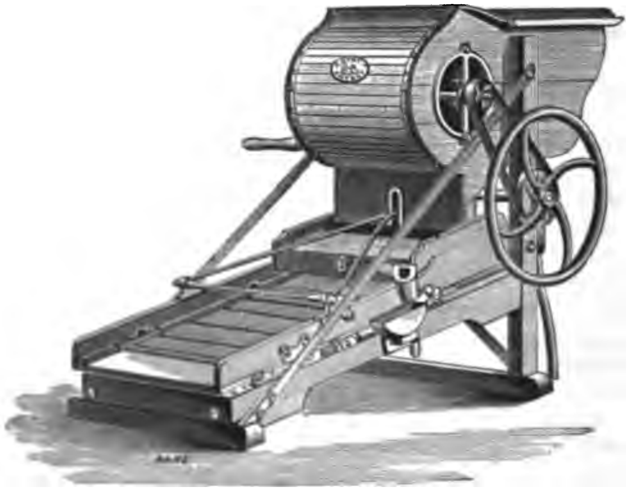


FIG. 115.—BOBY SCREEN WITH BLOWER.

In this machine the patentees have endeavoured to produce a flat screen to meet the requirements of those who do not wish to go to the expense of purchasing an adjustable or rotary screen. It is made with a series of screening surfaces arranged in steps, so that the corn, in passing over, drops from one screening bed to another, thus securing a more perfect action than if the bed were continuous. The wires are of steel, and of triangular form, resting on revolving padded rollers. These

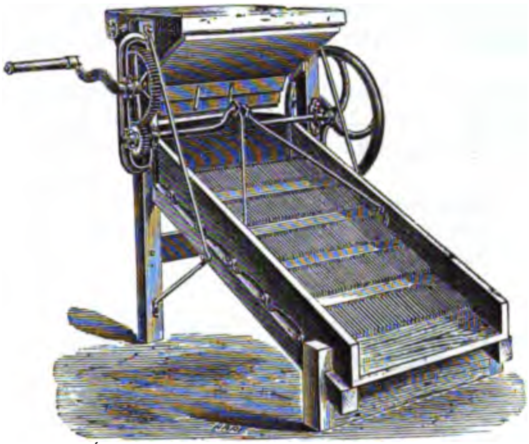


FIG 116.—COLEMAN STEP-SCREEN.

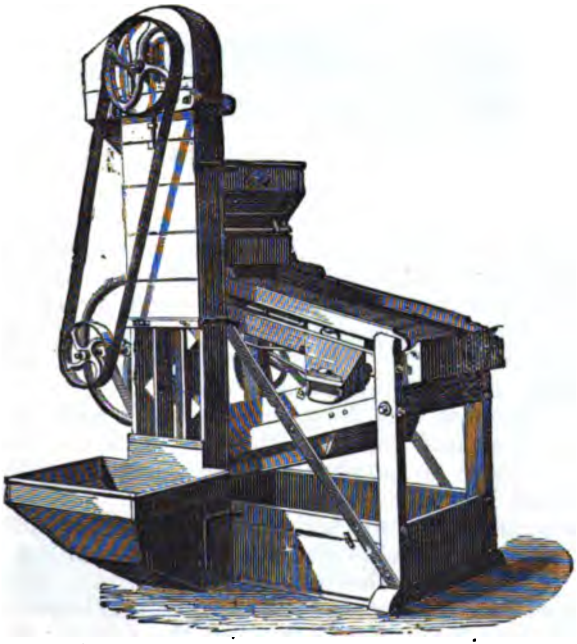


FIG. 117.—GRETTON AND ABBOTT'S SCREEN.

keep the spaces clean, and prevent all wear in the wires themselves. This is a matter of importance, for when washers are used in cleaning, it is impossible to preserve permanently the original size of the spaces, the wires speedily wearing so as to allow larger corn to pass through than was originally intended.

A still further development of this type of machine is Gretton & Abbott's patent separator, for removing broken or damaged corn, seeds, stones, &c., attached to a Boby screen. (See Fig. 117.)

In this machine the grain first passes over the Boby screen, which removes stones or other large substances, and separates the thin kernels from the bulk. These are delivered at the side of the screen, separately, from spouts, while the large grain passes on to a Gretton and Abbott's separator, which is fixed underneath the screen, and worked from the same spindle. This separator removes all seeds and broken kernels of barley, and gives a much more perfect sample for malting. It is fitted with elevators, as shown in the engraving, but when practicable it is desirable to feed it from the floor above.

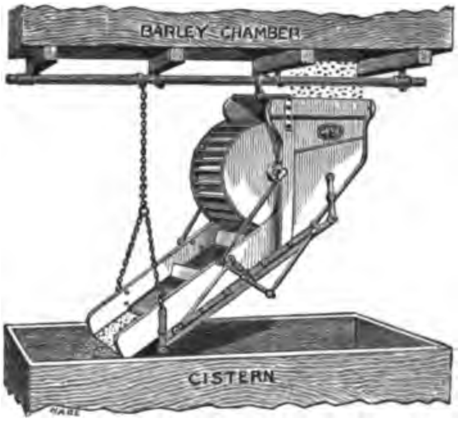


Fig. 118.—Automatic Screen.

One invention of Mr. Boby, in connection with his screen, is very ingenious and useful, as the weight of the corn to be screened is made to supply the motive power needed. (See Figs. 118 and 119.)

This screen is entirely self-acting and self-cleaning. An overshot or breast-wheel is placed in such a position that the grain in passing from the hopper to the screen causes it to revolve, and by means of this wheel, motion is imparted to the cleaning collars between the wires of the screen; the spaces are thus kept free from substances which would otherwise collect in them and render the screen useless.

This screen is adapted for use, as represented in the figure, between the granary-floor and the steep. It can be moved along the iron rod to any shoot or opening in the floor. When once set to work, it requires very little attention. The underside is fitted with sacking to receive the thin and refuse grain, which runs away into a sack or other receiver. A space of about four feet is required between floor and cistern for the smallest sized screen.

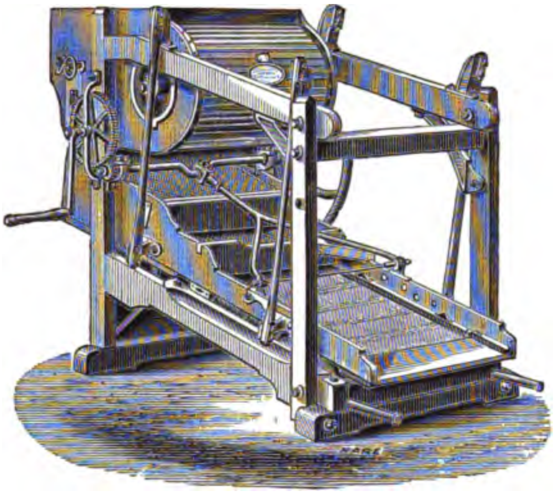


FIG. 119.—SELF-ACTING MALT-SCREEN.

The same arrangement is adapted to the ordinary Boby screen, as in Fig. 120. This screen is practically self-acting, and is remarkably cheap, the prices being :—

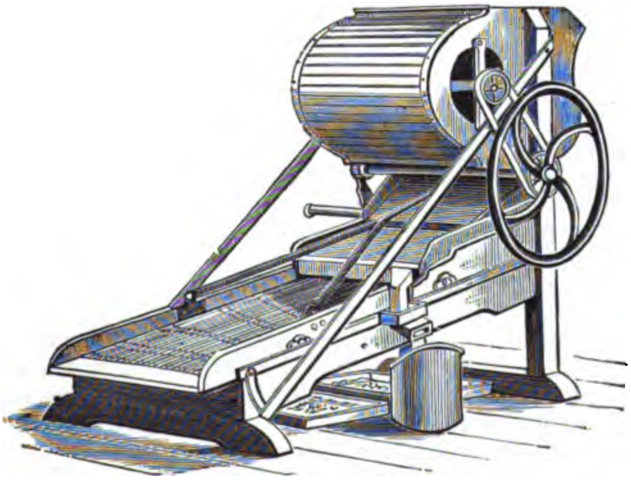


FIG. 120.— SELF-ACTING MALT-SCREEN.

To screen about 80 bushels per hour ...	£6	10	0
,, ,, 100 ,, ,, ...	8	10	0
,, ,, 160 ,, ,, ...	10	10	0

A great diversity of other flat oscillating screens, similar in outline and nature of work done, are made by makers too numerous to specify or describe.

The number and variety of rotary screens exceed even the other kinds.

One form has been very extensively used, made by Penney and Co., Lincoln. This screen (Fig. 121) is capable of ready adjustment to suit the different kinds and qualities of grain. It is not liable to derangement, but, with fair treatment, is found to be thoroughly efficient. There is no danger of the meshes becoming clogged up by damp grain, wild oats, or dirt, which is the case with many screens having short meshes, or in which the wires are placed diagonally; for these screens, being so constructed that the screening wires may be brought nearer to each other, or set further apart at pleasure, can not only be adjusted to dress the various sizes of grain, but when opened fully, they clean themselves of dirt by allowing everything to fall through. The long narrow meshes of these screens have also the advantage of taking out bits of straw, awns of barley, &c.

The thorough screening of the grain is ensured by the sheet-iron worm in the interior of the screen, which causes the grain to pass evenly along from the feed to the delivery end, without rushing forward too rapidly when crisp and dry, or accumulating when damp—a defect often experienced in those screens worked at an angle of inclination. The meshes are kept clear by the revolving brush, and the steel springs which regulate the width of the meshes, keep the wires at equal distances apart from one end of the screen to the other, at whatever pitch or degree of closeness they may be adjusted.

These screens are made in two varieties, viz., with the steel springs which regulate the width of the meshes outside or inside. Those with the springs outside, owing to the unobstructed screening surface presented, cleanse the grain more thoroughly, whilst those with springs inside have the advantage of requiring less power to work, and are kept much cleaner in operation, the revolving brush being continually upon the surface of the screen.

These screens (Class A) are adapted for separating and finishing for market, grain that has passed a winnower, or as it leaves a double-blast threshing-machine; and are suitable for finishing barley for malting purposes, provided the sample is free from substances larger than the grain itself.

Three distinct separations are made by screens of this class; the dirt, tail-corn, small seeds, &c., falling through the meshes of the screen at A (see illustration), corn of second quality at B, and the best passing out at the end of the machine. Or, if desirable, the screen can be adjusted so that two separations only are made, the dust, tail, seeds, &c., falling underneath the machine, and the good grain being delivered at the end.

This machine (Fig. 122) is similar to Class A, with the addition of a blowing apparatus or fan, which cleanses the grain from dust, chaff, awns, and all light substances before entering the adjustable screen, the meshes of the screen finally separating it from the tail, &c., into seconds and best, as already described.

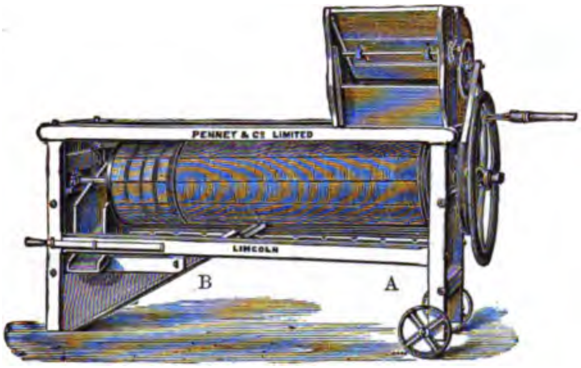


FIG. 121.—PENNEY'S GRADING SCREEN, CLASS A.

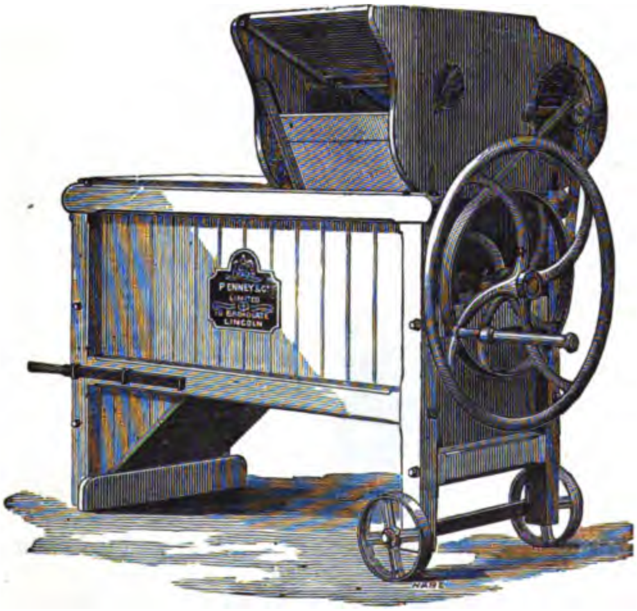


FIG. 122.—PENNEY'S SCREEN, WITH BLOWER.

This screen is constructed in two parts, the second having wider meshes than the first, and is designed for grain containing stones, dirt, tares, peas, or other substances larger than the corn. The dust, tail-corn, and second quality are separated by the first part precisely as in Class A; the stones and large refuse are delivered by a spout at the side, and the best grain passes out at the end of the machine. By a further improvement, the second part, or "stone separator," can be readily adjusted also.

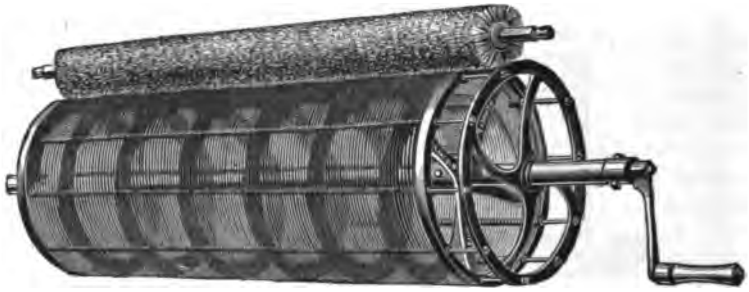


Fig. 123.—Penney's Corn-Screen.

A fan is frequently attached to this class of machine.

Fig. 123 shows clearly the mode of construction of the barrel of these screens and method of cleaning it. The Kittool brush revolves with the screen and sends back all kernels, stones, &c., of such a size that they lodge between the wires, and the permanent retention of which would eventually choke the screen.

Another adjustable screen is made by Coleman and Moreton, of Chelmsford.

The idea is steadily gaining ground with some intelligent maltsters, that it is desirable, and even necessary, to do still more to barley prior to steeping than any of the above screens can effect. The end desired is to remove all broken or damaged kernels, &c., and to leave the good grain graded into several distinct varieties. Numberless inventions in Germany, France, and America have been made to effect this, and a few in Great Britain.

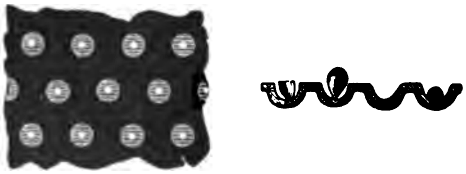


Fig. 124.—Cylinder of Half-corn Separator.

The separation of broken corn and seeds is effected by passing it through slowly revolving cylinders, which have a great quantity of indentations upon their surface. Seeds or half-corns drop into the cavities and are carried to a higher level in the rotation of the drum than whole corns, and can accordingly fall upon a shelf and be conveyed away. Fig. 124 shows the plan and section of the form of indentation which is at present best liked.

The application of this plan has been brought to practical use by Mayer, Schwalbe, L'huillier, Pernollet, Kurthe, Ainé, Van Gelder, Schultz, Pictet, and many others. All the machines of this class are very costly, difficult to work, tedious, and very limited in capacity. Still the work they accomplish is so good that even were they slower and dearer they should be universally used.

Van Gelder's patent maltsters' separating and grading machine is typical of the majority of the best of these screens, as it completely screens, cleans, and grades all barley passed through it.

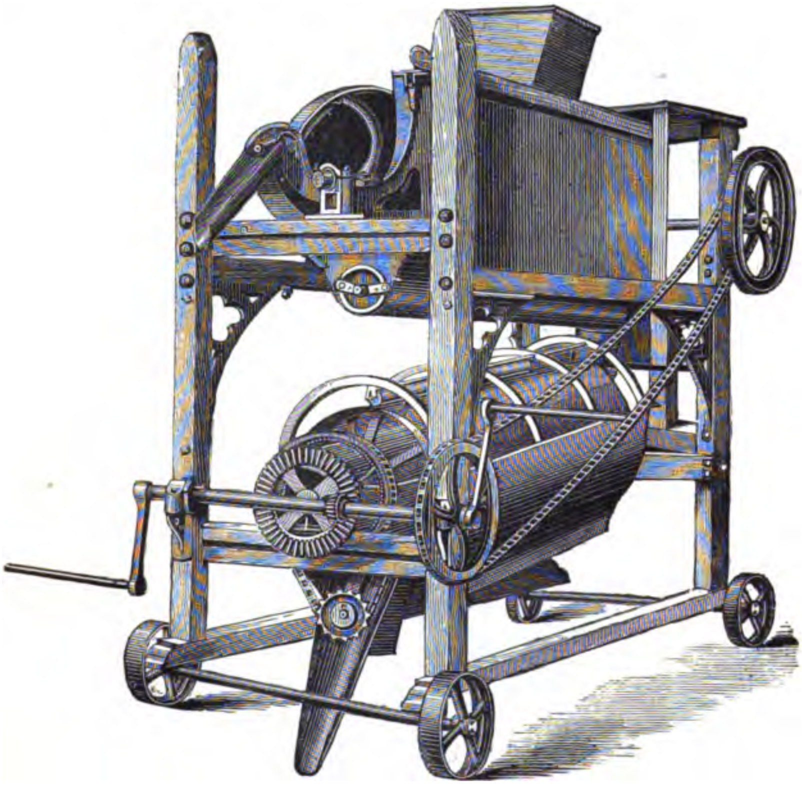


FIG. 125.—VAN GELDER'S SCREEN.

In this machine the upper cylinder takes out half-corns, and the lower cylinder takes out dust, stones, and vetches. The barley is divided into two grades. The capacity of the screen (as illustrated, Fig. 125) is about 35 bushels per hour, and the dimensions are 9 ft. long, 7 ft. 6 in. high, and 3 ft. 6 in. wide.

When larger capacity is desired, a greater number of cylinders are employed, and the form of construction differs. (See Fig. 126.)

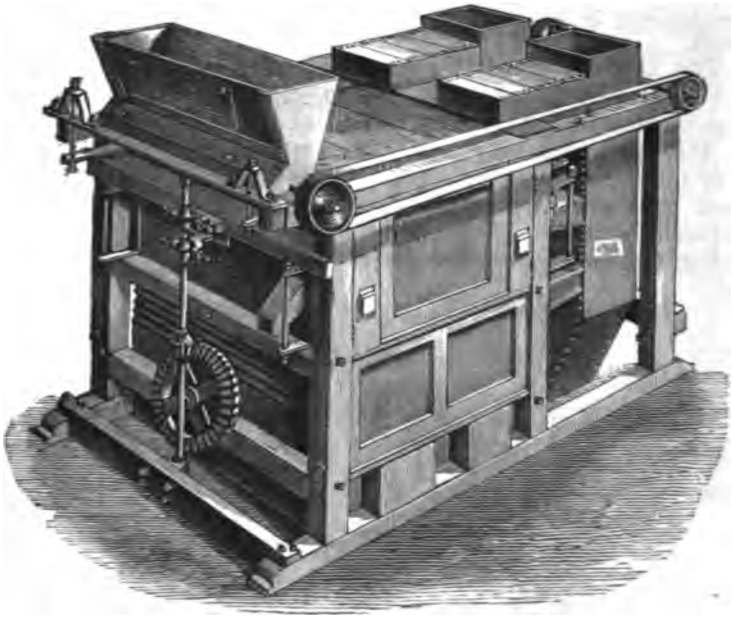


FIG. 126.—VAN GELDER GRADER.

MALT-SCREENS.

Malt-screens are nearly as numerous and varied as barley-screens. The form chiefly used in Britain is as Fig. 127.

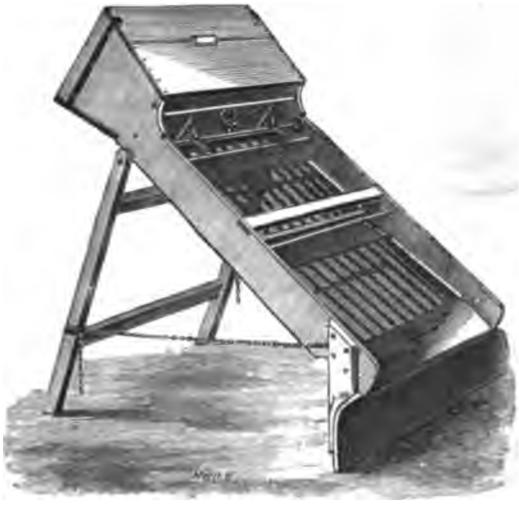


FIG. 127.—MALT-SCREEN.

This screen has the wire arranged in a manner that is very lasting and efficient.

A series of steps are introduced in the wire part, in falling over which, the malt is more effectually deprived of the chives and dust than in passing over a screen with a flat surface.

The hopper is fitted with sliding board and screw for regulating the feed.

Price (wire part—3 ft. 6 in. by 4 ft. 4 in. long) £5 10s. 0d.

Upon the Continent rotatory screens are preferred for the removal of the combes or chives; and in the breweries of Britain a very excellent type of malt-screen is in very general use, made and patented by Nalder & Nalder, of Wantage.

These screens separate dust, thin malt, and stones from malt prior to grinding. They are constructed with wires, arranged as Figs. 127, 128, 129, 130.

The following Figs. (128—130) illustrate the method of fixing the spirally wound wires of the rotatory screen into the notches of the longitudinal bars, when rivetted over. These notches being cut by patent machinery, unfailing accuracy is obtained. The small wires are of steel.

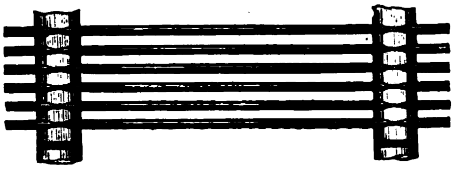


FIG. 128.—NALDER'S SCREEN.

Fig. 128 shows the fine mesh as used for taking out the malt dust.

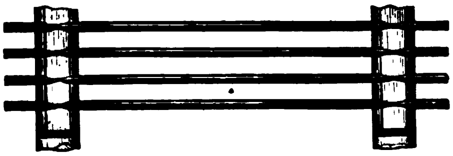


FIG. 129.—NALDER'S SCREEN.

Fig. 129 shows the mesh as used for taking out thin malt.

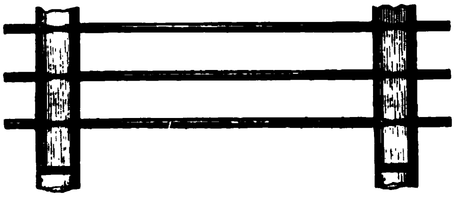


FIG. 130.—NALDER'S SCREEN.

Fig. 130 shows the mesh as used for separating stones from the head-malt.

Each of the above diagrams represents a small portion of the barrel drawn to full size—the small wires are the spiral, the large ones the longitudinal, as shown in Fig. 131.

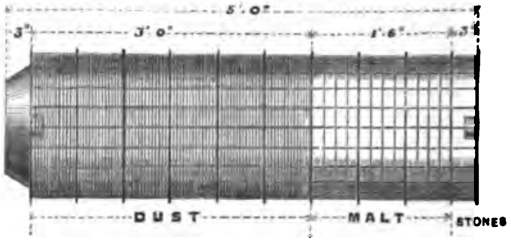


FIG. 131.—NALDER'S SCREEN.

The method of fixing and using these screens is sufficiently shown in the following (Fig. 132).

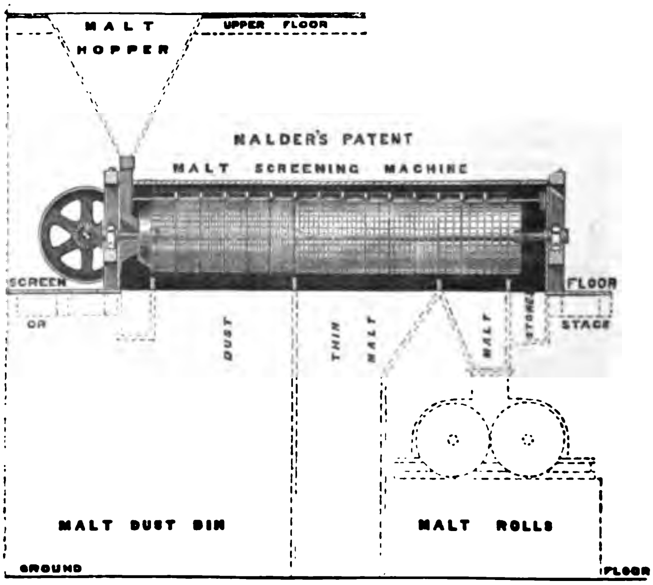


FIG. 132.—NALDER'S SCREEN, FIXED.

The above engraving represents a longitudinal sectional elevation of a class B machine in single form. In this the head malt falls directly from the screen-barrels into the roll hopper; the thin malt falls into a partition, to be separately crushed by the ordinary rolls, or falls directly into the hopper of a small pair of rolls, specially fixed for the purpose. The dust drops into the dust-bin, and the stones are conveyed away in suitable spouts to any convenient receiver.

It is preferable to have self-feeders to all screens of this sort, *i.e.*, an apparatus as shown by Fig. 133. This is a small receiving barrel fitted with a short screw-conveyor and driven from the spindle of the screen. The relative speeds are consequently always equal and the feed to the screen-barrel proportionate to its speed.

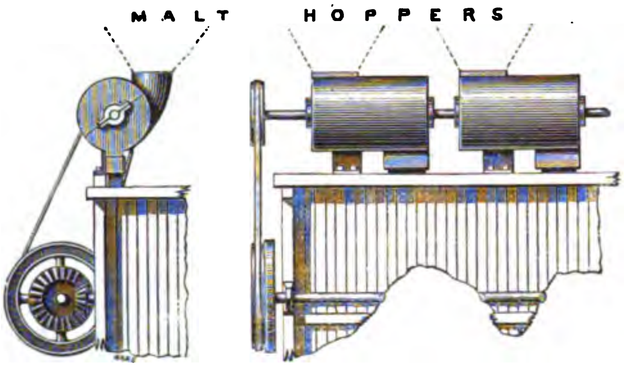


FIG. 133.—SELF-FEEDER.

Although these screens are very efficient and of great utility, they do not stop nails and other metallic fragments that are invariably to be found in all grain under every circumstance.

To arrest this metal a magnetic screen is very commonly employed.

These screens (Fig. 134) are very powerful magnets arranged as shown in the illustration. The malt in passing in a thin stream not exceeding one inch in thickness over the upper surfaces of the magnets rarely carries beyond the magnet any of the metal commingled with it.

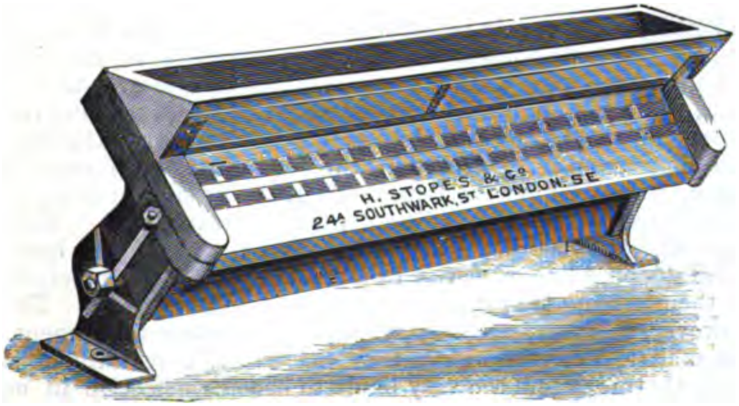


FIG. 134.—MAGNETIC SCREEN.

The average quantity of metal in malt is about one nail per quarter.

SHOVELS.—See Turners.

SLIPPERS.

In nearly all well regulated malthouses the workmen engaged in cisterns or on growing, drying, and screening or store-floors, are made to wear slippers, commonly of list or indiarubber.

On kiln floors or in cooling rooms, where malt is trodden to free it from combes, a form of slipper or patten is used which has securely attached to its sole a series of steel blades very similar to skate-blades and having sharp edges. These are found to remove the rootlets without damage to the malt.

SPARGERS.

It is always desirable to fix over all square cisterns a pipe or series of pipes filled with a large number of fine holes, which sparge or spray the steep-liquor in a uniform manner over the whole surface of the cistern. These pipes should always be of copper, fitted with unions for easy removal and cleaning.

Circular cisterns have frictionless revolving spargers.

STEAM BOILERS.

The form of boiler most commonly used by maltsters is of the Cornish or Galloway type. These are so generally known that it is needless to describe them.

STENCIL PLATES.—See Sacks.

TESTERS.—See Barley Tests.

THERMOMETERS.

Until comparatively recently thermometers have been used in only few malt-houses. Numerous varieties have now been tried, and the more useful are mentioned hereafter. As, however, the question of heats during all processes of malting is by far the most important, and also in consequence of the use of the thermometer to ascertain the temperatures of even the drying stage being so very limited, I treat the subject at greater length than in a few years' time may be requisite, *i.e.*, in the days when you cannot ask one hundred maltsters the heat of their steeping-liquor, or the heat in couch, and get ninety-five of them stating they "never tried it, so do not know." That, however, fairly represents the state of scientific attainment of the maltsters of Great Britain in this year of grace (A.D. 1885).

As thermometers are very liable to become defective in use, it is a matter of importance to every maltster to determine the accuracy of each thermometer in his possession. This is very easily and simply done in the following way:—

Place a quantity of ice granulated to about the size of small beans in a small vessel. Take care to have a hole in the bottom that admits of the escape of the water that is formed by the liquefaction of the ice. Place the thermometer in this ice, taking care fully to expose the bulb and to cover the whole column of mercury. When the mercury has become absolutely stationary, the thermometer should register 32° Fahr., 0° Cent., 0° Réaum. Any variation from these figures marks the degree of inaccuracy of the instrument at the cold end of the scale.

The scales of thermometers are so generally marked upon Fahrenheit's scheme in Great Britain that few others are understood. Upon the Continent of Europe, and in the laboratories of Great Britain, other scales are used, owing to the greater ease with which some calculations arising from considerations of temperature can be effected. The other scales used for these purposes are Celsius (Centigrade) and Réaumur.

The differences are considerable.

Fahrenheit places zero 32° below freezing, and the boiling point 180° above freezing, consequently we get the boiling point called 212°.

Réaumur and Celsius both call the freezing point of pure water zero, 0°.

Réaumur determines the boiling point at 80°, and Celsius 100°.

We therefore get the standards variously expressed—

		Fahr.	Cent.		Réaum.
—		0°=	− 17·7°	or	− 14·2°.
Water	Freezing point	32°	0°	,,	0°.
	Boiling ,,	212°	100°	,,	80°.
—		250°	121·1°	,,	96·9°.

A temperature exceeding 250° is never required in a malthouse for any purpose affecting the manufacture. It is, therefore, needless to tabulate a greater heat.

The following table shows at a glance each degree Centigrade from zero Fahrenheit to 120° Centigrade, and the corresponding temperatures upon the Fahrenheit and Réaumur scales.

Cent.	Réaum.	Fahr.
—17·7°	—14·2°	0°
16	12·8	3·2
15	12	5
14	11·2	6·8
13	10·4	8·6
12	9·6	10·4
11	8·8	12·2
10	8	14
9	7·2	15·8
8	6·4	17·6
7	5·6	19·4
6	4·8	21·2
5	4	23
4	3·2	24·8
3	2·4	26·6
2	1·6	28·4
—1	—0·8	30·2
+0	+0	+32
1	0·8	33·8
2	1·6	35·6
3	2·4	37·4
4	3·2	39·2
5	4	41
6	4·8	42·8
7	5·6	44·6
8	6·4	46·4
9	7·2	48·2
10	8	50
11	8·8	51·8
12	9·6	52·6
13	10·4	55·4
14	11·2	57·2
15	12	59
16	12·8	60·8
17	13·6	62·6
18	14·4	64·4
19	15·2	66·2
20	16	68
21	16·8	69·8
22	17·6	71·6
23	18·4	73·4
24	19·2	75·2
25	20	77
26	20·8	78·8

Cent.	Réaum.	Fahr.	Cent.	Réaum.	Fahr.
27°	21·6°	80·6°	74°	59·2°	165·2°
28	22·4	82·4	75	60	167
29	23·2	84·2	76	60·8	168·8
30	24	86	77	61·6	170·6
31	24·8	87·8	78	62·4	172·4
32	25·6	89·6	79	63·2	174·2
33	26·4	91·4	80	64	176
34	27·2	93·2	81	64·8	177·8
35	28	95	82	65·6	179·6
36	28·8	96·8	83	66·4	181·4
37	29·6	98·6	84	67·2	183·2
38	30·4	100·4	85	68	185
39	31·2	102·2	86	68·8	186·8
40	32	104	87	69·6	188·6
41	32·8	105·8	88	70·4	190·4
42	33·6	107·6	89	71·2	192·2
43	34·4	109·4	90	72	194
44	35·2	111·2	91	72·8	195·8
45	36	113	92	73·6	197·6
46	36·8	114·8	93	74·4	199·4
47	37·6	116·6	94	75·2	201·2
48	38·4	118·4	95	76	203
49	39·2	120·2	96	76·8	204·8
50	40	122	97	77·6	206·6
51	40·8	123·8	98	78·4	208·4
52	41·6	125·6	99	79·2	210·2
53	42·4	127·4	100	80	212
54	43·2	129·2	101	80·8	213·8
55	44	131	102	81·6	215·6
56	44·8	132·8	103	82·4	217·4
57	45·6	134·6	104	83·2	219·2
58	46·4	136·4	105	84	221
59	47·2	138·2	106	84·8	222·8
60	48	140	107	85·6	224·6
61	48·8	141·8	108	86·4	226·4
62	49·6	143·6	109	87·2	228·2
63	50·4	145·4	110	88	230
64	51·2	147·2	111	88·8	231·8
65	52	149	112	89·6	233·6
66	52·8	150·8	113	90·4	235·4
67	53·6	152·6	114	91·2	237·2
68	54·4	154·4	115	92	239
69	55·2	156·2	116	92·8	240·8
70	56	158	117	93·6	242·6
71	56·8	159·8	118	94·4	244·4
72	57·6	161·6	119	95·2	246·2
73	58·4	163·4	120	96	248

The rules for conversion of any given temperature of one scale to the corresponding degree of any other, are comparatively simple and easy of remembrance.

These different scales are known to be at boiling, or 212° Fahr., as follows:—

212° Fahr. 100 Cent. 80 Réaum.

As 32° Fahr. mark the difference of the freezing point of water, between the Centigrade, or Réaumur, or Fahrenheit scales the actual difference is, consequently—

180° Fahr. 100 Cent. 80 Réaum.

Bearing in mind these facts, it is obvious that if it is desired to convert any particular temperature marked upon a Fahrenheit scale into Réaumur or Centigrade, we must first subtract 32°; and if Réaumur degrees are required, multiply the product by 80, and divide by $180 = \frac{4}{9}$; or if degrees Centigrade, then the product must be multiplied by 100, and divided by $180 = \frac{5}{9}$.

This, still more simply, can be expressed.

Degrees Fahr. into degrees Réaum.—

$$\frac{(^\circ\text{F.} - 32) \times 4}{9} = {}^\circ\text{R.}$$

Degrees Fahr. into degrees Cent.—

$$\frac{(^\circ\text{F.} - 32) \times 5}{9} = {}^\circ\text{C.}$$

Degrees Réaum. into degrees Cent.—

$$\frac{^\circ\text{R.} \times 10}{8} = {}^\circ\text{C.}$$

Degrees Réaum. into degrees Fahr.—

$$\frac{(^\circ\text{R.} \times 9) + 32^\circ}{4} = {}^\circ\text{F.}$$

Degrees Cent. into degrees Réaum.—

$$\frac{^\circ\text{C.} \times 8}{10} = {}^\circ\text{C.}$$

Degrees Cent. into degrees Fahr.—

$$\frac{(^\circ\text{C.} \times 9) + 32}{5} = {}^\circ\text{F.}$$

Illustrations:—

Supposing we require to know the corresponding values of 50° on all the scales.

50° Fahr. converted to degrees Réaum.—

$$\frac{(50^\circ - 32) \times 4}{9} = 8^\circ\ \text{R.}$$

50° Fahr. converted to degrees Cent.—

$$\frac{(50^\circ-32)\times 5}{8}=10^\circ \text{ C.}$$

50° Réaum. converted to degrees Cent.—

$$\frac{50^\circ\times 10}{9}=62\cdot 5^\circ \text{ C.}$$

50° Réaum. converted to degrees Fahr.—

$$\frac{50^\circ\times 9+32}{4}=144\cdot 5^\circ \text{ F.}$$

50° Cent. converted to degrees Réaum.—

$$\frac{50^\circ\times 8}{10}=40^\circ \text{ R.}$$

50° Cent. converted to degrees Fahr.—

$$\frac{50^\circ\times 9+32}{5}=122^\circ \text{ F.}$$

For general use upon floors, cistern, and kiln, the two thermometers (Figs. 135, 136) are generally liked.

FIG. 135.—MALTSTER'S THERMOMETER.

When it is desired to register or indicate the heat of malt or air in kilns, at any required spot at a distance, the electric thermometer is of value.

FIG. 136.—STOPES' THERMOMETER.

For these doubly-adjusting electrical Sixes thermometers, it is claimed that the indices can be set for any desired range of temperature, large or small, and at any part of the thermometric scale; and they can be so arranged that they are solely under the control of the person who sets them, and therefore they cannot be tampered with after they are once set. If the temperature either rises above or falls below the set limits, a bell is sounded, or some other signal given, at any desired distance from the instrument. The thermometric fluids are hermetically sealed in the tubes, so that no entrance of air is possible. This is an accurate thermometer and is made to give warning of an excess of both heat and cold, and it is, at the same time, adjustable with ease and certainty. Price £3 5s.

A form of self-recording thermometer for use on floors or kilns is in use in Germany by which a pointer marks in a slowly revolving ruled sheet the exact temperature of floors.

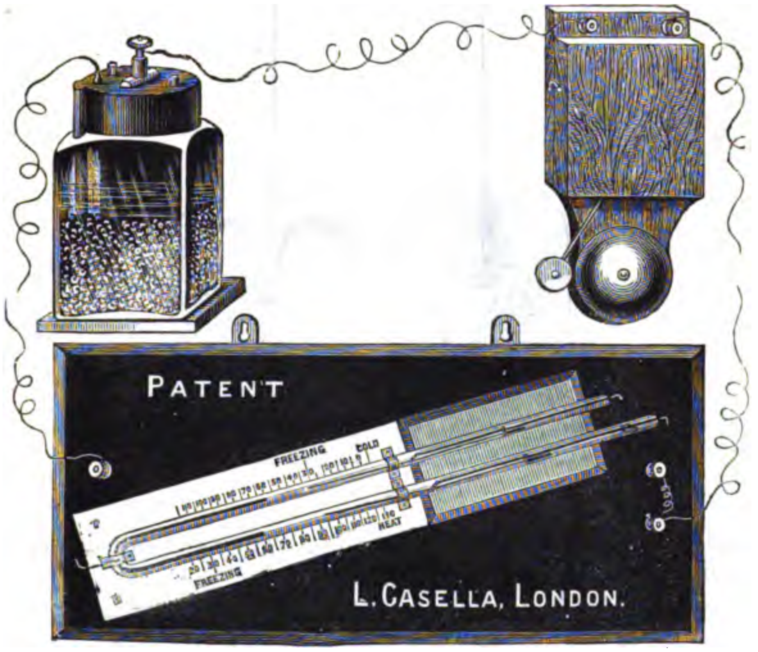


Fig. 137.—Casella Thermometer.

This is not mercurial, but depends upon the expansion of metal. Its great advantage is that it continuously records for a whole week the actual temperature at every hour of the day and night.

This instrument is very easily adjusted to indicate electrically at any distance a maximum or minimum degree of heat desired.

TURNERS.

The stirrers and turners now used in malthouses are peels, prods, ploughs, prongs, forks, shovels, skimmers, and screws. Of these, peels, prods, and skimmers are of wood, and are used for stirring, turning and skimming off or removing the corn in steep or on floor.

Forks and shovels are of wood, iron, steel, and tin.

Screws are of iron and gun-metal.

Wooden shovels, like Fig. 138, or forks, like Fig. 139, are made of beech, willow, or sycamore. They are called deep or barn shovels, and flat, turning, or kiln shovels.

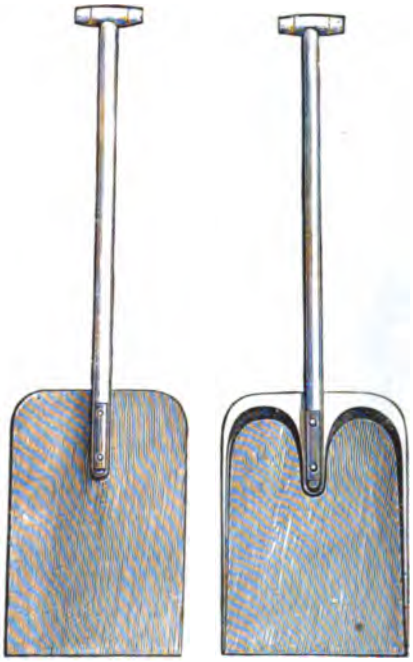


Fig. 138.—Shovels.

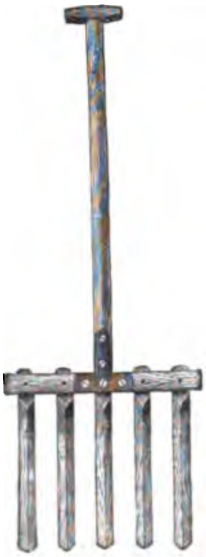


Fig. 139.—Wooden Fork.

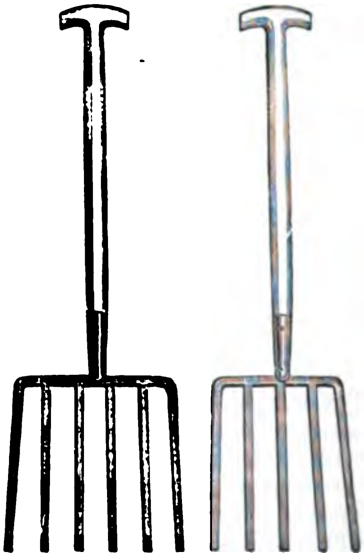


Fig. 140.—Steel Forks.

Tin shovels are generally used in cisterns.

Steel shovels are used on kilns or for furnaces.

Very numerous types and sizes are used. Flat beech turning shovels range from 12 in. to 18 in. in width.

For turning great depths of grain germinating upon growing floors or steeping in cistern the Saladin turner is commonly employed. (See Fig. 47, p. 233.)

The application of this screw is explained by Fig. 48, p. 234.

VALVES.

Water-, gas-, steam-, and grain-valves are used in malt-houses. These, necessarily, are of very varied designs, and any useful form, even if identical with those used in Pompei, can be employed.

The best form of discharge valve for cisterns yet used is probably that designed by me. (Fig. 11, p. 192.)

With a full clearway of 7″ dia., these valves empty a cistern or gelatiniser with great rapidity, and never choke.

WASHERS.

It is desirable to wash barley prior to steeping, but at present it is very rarely done. The Stopes' barley-washer is illustrated by Fig. 141.

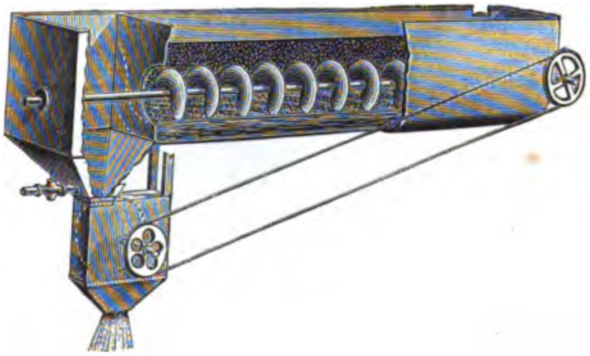


FIG. 141.—STOPES' BARLEY-WASHER.

This is an improvement upon the washer made by M Galland. The barley falls in at one end of the washing-trough, and is transported by the screw to the small hopper at the opposite end. Here it meets an upward stream of pure water, which, flowing along in the opposite direction to the screw, discharges at the feeding end, and carries with it all the finer and floating particles brushed or washed from the corn. The inlet-water valve is larger than the bottom orifice through which the barley and water fall, consequently a small proportion of the water flows continually up through the water-trough. The combined water and corn fall into the steeping-cistern over a small overshot waterwheel, which communicates the power needed to turn the screw-conveyor. This makes the machine practically self-acting, the only attention needed being to regulate the relative flows of corn and water.

WEIGHING-MACHINES.

Barley and malt are sold by weight as well as measure in many cases. Consequently a mean of weighing is necessary.

The methods used and weights expressed vary needlessly very greatly.

Beam-scales, balances, springs, steelyards, and more complex machines are all in use.

The weights commonly employed are lbs., stones, quarters, centals, hundredweights and tons.

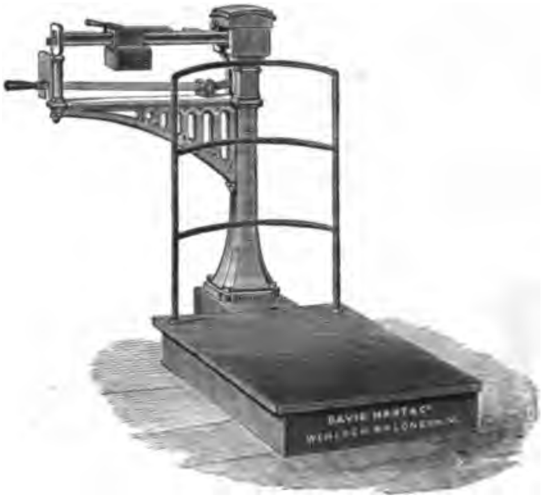


FIG. 142.—HART'S WEIGHING-MACHINE.

Fig. 142 represents the simpler form of table scales now used. This machine is of excellent design, and as it has no loose weights, is always of full service. A great diversity of machines somewhat similar in working and appearance are also in use.

A totally different machine has been recently invented, and is very much approved. It is known as Reuther's patent automatic weighing and registering machine, and it is a very reliable and useful instrument for weighing barley when delivered into receiving bins, or malt after cleaning, prior to despatch from the malt-house.

The principle of this machine (Fig. 143) is that of the ordinary scale-beam, and, essentially, it consists of an equal-armed scale-beam having its three axes in the same line, with the scale for the weights at one end, and at the other the receiving vessel for the material to be weighed. Improved automatic mechanical arrangements close the inlet the moment the exact weight required has entered this receiver; they instantly open the discharge-flap at the bottom, and close it when the grain has run out. The inlet is then re-opened, and each weighing registered on the dial.

A special stop-motion is also applied, by which the machine can be set to stop when any desired number of weighings has been made, as, for instance, when a certain number of quarters are to be cleaned, or sacks to be filled. Say 50 are needed. The index is referred to; if it stands at, say, 2,450, the stop would be set at 2,500. Then directly the number 50 had been weighed, the motion of the machine would be arrested automatically.

It is also made so that the correctness of the weighings can be tested at any time by simply hooking a lever into a catch, and without having to remove the charge weighed to any other weighing-machine or scale, as the real weight of the holder and contents can be ascertained. The accuracy of these machines has been tested, and proved to attain the remarkably high standard of error of only 1 lb. in 80 tons.

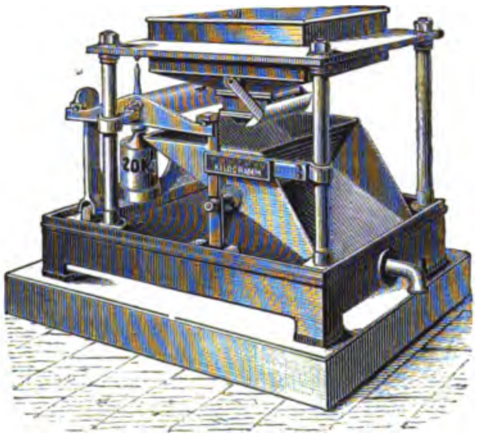


FIG. 143.—REUTHER'S WEIGHING-MACHINE.

The counter connected with the mechanism is so arranged that the dial-plate shows the weight of each charge, and also the exact weight of all that has been weighed for a week, or a year. It may be adapted to show bushels, quarters, or any unit desired. The dial has six, or in the larger machines, seven figures, so that it will register up to one or ten millions respectively. When, after more than a year if the machine is in constant action, it reaches the maximum, it goes back automatically to 0, and recommences.

A cover is provided for each machine, which covers all the mechanism, leaving only the dial of the counter exposed. The machine is thus protected from accidental or malicious interference.

My own experiences as a student have induced me to devote more space to the description of tools than is common in works of this class. In reading old books, I frequently find apparatus vaguely alluded to, and I long for fuller details or drawings. Assuming that others may possibly have the same desire, has made me spend the energy and time necessary to accomplish this task, which at the best is invidious, imperfect, and comparatively useless to the present generation, and may be sneered at as needless by the succeeding ones.

PART IV.—PROCESSES OF MANUFACTURE.

CHAPTER XVIII.

SELECTION AND PREPARATION OF MATERIALS.

Selection and Preparation of Materials:—
Vitality. Cleanliness. Screening. Washing. Grading. Cost of Grading. Benefits of Grading. Sweating. Necessity for Sweating. English and Shipped Corn. Absorption of Moisture by Grain. Opinions of Champion, Faulkner, Ford, Schultze, &c. Benefits of Sweating. Uniformity of Growth. Bins. Systems of Working. Number of Men Required.

HAVING disposed of all the preliminary and surrounding aspects and stages of malting, it will be now comparatively simple to deal directly with the actual work of making malt.

Careful perusal of some of the preceding chapters will teach, in a detailed form, much concerning the materials and apparatus employed, the buildings used, and the ends sought.

It has been made plain that to make malt well it is essential—

I.—To have a malting so arranged that the work can be done properly and economically.
II.—That proper material must be employed.
III.—That the end sought must be understood, and the best means of its attainment must be practised.

Assuming these important points to be understood, it is now necessary practically to consider the modes of manufacture.

Barley or any other grain to be made into malt has to be steeped, grown, and dried.

Some maltsters fancy these three* operations cover their whole duty when making malt, and they ignore an operation which in itself is equally important.

All grain prior to use should be selected and prepared with great care. No selection can be so careful, nor preparation so elaborate as to be called wasteful, for a long lifetime may be spent without once seeing a sample of barley fit for the cistern before considerable preparation.

The steps of preparation commonly needed are—

I.—Cleaning.
II.—Grading.
III.—Drying or sweating.

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* Usually expressed by other writers as four processes, who consider couching as a separate process. It is preferable to regard it simply as a part of growing.

The selection of corn is a faculty best acquired in the market and malt-house under proper tuition. Artists or poets may be born, but a good judge of barley has to learn from the experience of others.

Taking the characteristics of corn already set forth (Chap. VIII., pp. 79-99) into careful consideration, and allowing the reasonings therein contained to be of some weight, the most important quality is the vitality of the grain. Nothing whatever need be done to grain which will not grow properly, unless, of course, it is deemed necessary to try to malt it.

Vital or live corn, no matter how good or bad it may be, requires to be cleaned; no matter how big or even it may be, it requires to be graded; and no matter how dry it may be, it requires to be sweated.

I have had numerous samples of barley submitted to me as being perfect, but I have yet to see any sample whatever clean enough or sufficiently even (uniform) to be fit for steeping prior to screening and grading.

No dust or dirt adhering to corn is of use or benefit in the process of malting. Much of the so-called dust and dirt is of a positively harmful character. The substances adhering to grain that are more readily putrefactive than live corn, are of themselves baneful and undesirable. The germs and spores of numerous ferments and fungoid organisms are visibly detrimental and destructive.

Proper screening, brushing, and washing, remove many of these evils.

The modes of arrangement for these operations necessarily vary too greatly to be described generally. Numerous simple and effective methods exist, but nearly if not quite all require to be carried to a more perfect point than any yet attained.

Grading grain is, if possible, still more important than cleaning it. As well might we give garments of one uniform size and pattern to men, women, and children alike, as steep and grow in one place all together—barleys, heavy and light, large and small, perfect and damaged, overgrown and undergrown. The resulting malt cannot by any possibility be so good as it might have been, had care been taken to ensure at least uniformity of size.

Grain can now be graded into classes in which every kernel is of one uniform length and width, and from which every foreign matter capable of separation has been removed. It is simply marvellous that practical men cannot see the immense advantages during steeping, growth, drying, and use, of only malting corn so selected.

Any machine which does not grade into at least three sizes of useful corn, and remove all broken kernels and defects, or rubbish of every kind, should be put on one side when it is desired to make malt of best quality.

The only practical objection that can be urged against elaborate and careful cleaning of grain is the expense.

At first sight this seems reasonable, for the cost of cleaning is necessarily considerable. In the first place, an efficient grader must possess a fan or aspirator, a series of cylinders and drums—each capable of removing a particular description of corn or refuse—elevators, and conveyors.

In many cases a receiver for dust has to be built, and very frequently the use of a grader necessitates the addition of motive power.

Consequently a grader to screen efficiently ten quarters per hour costs, complete, £700.

The cost of maintenance is also considerable, involving repairs and renewals, fuel, oil, and wages.

Allowing, therefore, ten per cent. for depreciation of machines, we find the cost of grading as follows :—

Prime outlay		£700
Annual cost—		
Depreciation...	£70	
Repairs, fuel, and wages ...	50	
		£120 per ann.

This cost, spread over 6,000 quarters of corn, means an outlay for screening of 4·8d. per quarter. To this has to be added the loss of barley by removal of refuse and thin corn. In extreme cases this amounts to nine and is rarely less than two per cent.

In smaller maltings the cost per quarter is larger relatively than in big houses. Assuming it, however, to be three times greater than it is, and that it costs 1s. per quarter, we find :—

	Per quarter. s.	d.
Cost of grading	1	0
Loss of corn, say three per cent. of the bulk, at the average price of barley for the past five years	1	0
Total loss and cost per quarter	2	0

This estimate is, in practice, too liberal.

The gain is the improved appearance of the malt, which commercially is worth to the maltster for sale at least 3s. per quarter, but in the average would be more, and the true increase of value to the brewer, which is actually worth at least 4s. per quarter, independently of the superior quality of the wort produced from malt which has been well cleaned and graded.

All barley is benefited by sweating on kiln prior to steeping, although considerable diversity of opinion is expressed by the various authors who have alluded to it.

Champion* strongly recommends the kiln-drying of corn five years out of six. He even goes so far as to warmly recommend the purchase of barley late in the season (say May), sweating it, and storing it for use in September and October, before the new corn is fairly fit for use, and he states the growth to be everything one could wish.

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* Wm. Champion, The Maltster's Guide (London, 1832), pp. 172—174.

Faulkner also says*:—"The kind of artificial sweating on "kiln at a temperature of 100° to 120° Fahr. has, no doubt, the "capacity of rendering many barleys out of condition more "suited for malting purposes; it takes the place apparently of "the sweat in stack, enlivens the vital germ, ensures equal "growth, vastly improves colour, and is a process that enables "English barleys to compete more successfully with those "grown under climatic conditions not often so disastrous as "those experienced by our English farmers."

In seasons that are late, or very wet during harvest, the ordinary effects of ricking, or the modification of the constituents of barley, consequent upon stacking, do not take place. The modern fashion of threshing by steam, either when carting or almost immediately after stacking, has to a maltster the unsatisfactory result of his purchasing samples that have not duly sweated. Such corn rarely grows regularly or well.

Cold, damp, and early corn is nearly always improved by sweating. Like every other operation in a malting, it requires discrimination, and the exercise of practical judgment. Broadly speaking, almost every sample that has not been influenced by damp sufficiently to start the acrospire is decidedly the better for a few hours upon the kiln, prior to storing or steeping. If the acrospire has moved, then drying does more harm than good. If any damage has been done in shipment or other mode of transit, it is better to steep promptly, and not to sweat such corn, provided such damage is considerable. Experiments made at the California Agricultural College tend to confirm the belief that no shipment of corn can be effected without absorption of moisture. Amongst shippers, an opinion is prevalent that grain absorbs sufficient moisture during transit to cover freight, and these experiments support the idea. Various kinds of grain were placed in a moist atmosphere, and the increased weight noted. The saturation was permitted for fifteen days, but it was found that an increase of 33 per cent. in weight of the grain was experienced in the first twenty-four hours. The results of the experiments were as follows.†

	First 24 hours.	Total in 15 days.
Oats	2·79 per cent.	7·7 per cent.
Barley... ...	1·45 „	7·0 „
Wheat... ...	2·45 „	6·56 „

It was computed that perfectly dry grain at a temperature of 65° Fahr. would absorb as follows:—

Oats	29·08 per cent.
Barley...	28·17 „
Wheat...	25·02 „

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* F. Faulkner, The Theory and Practice of Modern Brewing (London, 1884), p. 18.

† Engineer, July 28, 1882, p. 63.

Until these figures are confirmed by fuller experiment, they must be regarded as being very high and practically never attained. They, however, point very clearly to the desirability of sweating sound and (so-called) dry parcels of barley, that have had a voyage, as all corn shipped is necessarily damped unequally.

Ford* says: "Barley may be dried at a temperature under "the corn not exceeding 130°. I prefer 120°, corn not to "exceed 3 in. in depth. If the heat is carried above 130°, "vitality is impaired. Malted grain dried at a heat above 170° "will, if sown in the earth again, vegetate, but not sufficiently "strong to bear seed." Dr. Schultze contends that barley with a small percentage of grown corn is capable of making fair malt. (See Barley, p. 75). Sweating such barleys, however, is not desirable.

Sweating is best carried on at a low uniform temperature, rarely exceeding 105° Fahr.

The main benefits of sweating are (1) the greater freedom from evil, and much greater sweetness and safety during storage; (2) the reduction of the grain to a uniform degree of dryness, with consequent uniformity of absorption of moisture during the steeping. Barley, properly and thoroughly dried, never heats in the granary, even if stored in bulk at great depths.

It is generally an advantage to allow barley to remain in bins for a fortnight after sweating, prior to steeping. If it is intended to store it in deep bins, it is always desirable to cool before storing, and not to put it directly into bins from kiln.

By cleaning and grading each consignment or growth ot barley as it is received at the malt-house, it is possible to keep all the head or best corn separated from other growths, if sufficient bins are empty, and the bulk delivered amounts to a wetting.

If the bulk is less than a wetting, then other corn must be necessarily added to make up a steep, unless it is a house with two kilns and double or quadruple cisterns, in which case half a steep can, for any special purpose, be resorted to.

It is desirable to keep corn as much separated as possible, for the admixture of growths of corn inevitably causes a deviation from the best time for steeping or soaking of either or both samples, and a necessary difference in growth, in the majority of cases.

It nevertheless remains a matter of theory (which I have abundantly proved in practice) that it is preferable to mix two different growths of barley, uniform in size, than to steep the whole of a growth just as received with its usual admixture of small corn, broken kernels, refuse, &c.

To illustrate this important point more fully. A house wetting 50 quarters every other day (therefore, a hundred-quarter house) receives 50 quarters of barley from a particular farm, all of one growth. This, if screened, might lose three bushels of rubbish and dirt, and three quarters five bushels of thin corn. It would be preferable to add four quarters of any similar corn that could be taken (which also was freed from dirt and thin corn) than to put into cisterns the three bushels of dirt and the quantity of thin corn, for the double reason that even a small quantity of dirt is very objectionable, and it is almost as bad to put thin corns under the same conditions as stout plump kernels.

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* Malting and Brewing, p. 128.

Probably the greatest gain derivable from careful grading is the consequent removal of damaged corns or half-kernels. These can under no possibility be of use in malt, but in every way are objectionable and bad. Not only are they bad in themselves, but they become the centres or hotbeds of infection to healthful corns. Mould and fungoid growths find in them the best possible centres for propagation, and from them they disseminate themselves throughout the mass.

This is readily proved by inspecting the appearance at loading on kiln of two different steepings of the same growth of barley, from one of which the half-corns have been removed, whilst the other has been simply screened. Should the weather and conditions of the house at all favour the growth of mould, the one floor will be visibly blue, and smell distinctly putrid; the other will be clean and pure.

Maltsters may not attach much importance to this, but the day is fast coming when *brewers* will, for the lessons it teaches are being rapidly learned. The ravages mould is now permitted to perpetrate every day, entirely through the ignorance of maltsters, is a thing that a more enlightened generation will not possibly tolerate. The one thing that will do most for its removal, is the proper grading of corn, and the separation of defective kernels and dirt.

Should barley be kept from one season to another, it is very desirable not only to clean and grade it, but also to kiln-dry it very carefully prior to delivery to bins. Dirt and mould are both bad things, but their power to do evil is largely reduced when barley is dry. Dampness, on the other hand, is capable of entirely killing barley when it is perfectly clean and free from mould. Numerous experiments, already alluded to, or detailed by Haberlandt, de Saussure, and others, have conclusively proved that one of the main factors in the destruction of vitality in seeds is moisture.

Common sense teaches the desirability of having corn clean prior to lengthened storage, and the benefit of removing from it all refuse and useless matter.

For further remarks upon this subject, see Chaps. VIII., X., XI., XIX. Wheat, oats, and rye are all equally to be understood when barley only is spoken of, throughout this chapter.

A man single-handed can malt 12 to 15 quarters every four days, or three times a fortnight, in the slovenly manner generally found in small one-man houses.

A fifty or sixty-quarter house requires three, four, or five men, according to the system upon which it is worked. In the

English system, it is wise to allow a maximum of 12 quarters per man, if it is intended to be grown, screened, and worked honestly and properly.

There are several slight differences of working houses adopted in this country, which go under the names of the places in which they originate or are most practised, or of their inventors—such as Galland's, Marbeau, Stopes', the Ware, Newark, Burton, Essex, Scotch, &c. These variations are chiefly interesting to maltsters, and consist of differences in duration of steep, sprinkling on floor, growth of acrospire (or plumule), extent of withering, and duration and extent of drying, &c.

The widest difference is that between the ordinary English system and the pneumatic system.

CHAPTER XIX.

GERMINATION.

STEEPING, COUCHING, FLOORING, SPRINKLING, WITHERING.

" The main object of malting is the production of the peculiar albuminous bodies
" grouped together under the term diastase. This may be a convenient term; but
" the properties of diastase are not peculiar to albuminous matter in malt, being
" found in other products, animal and vegetable."—PROF. GRAHAM, Cantor Lectures, *Journ. Soc. Arts*, 1874.

Steeping.—
Four Essential Conditions. Fermentation. Ford's Definition of Germination. Common Method of Steeping. Temperature of Steep-liquor. Experience. Conditions Requisite. Oversteeped Barley. Bavarian Plan. Prolonged Steeping. Time. Quantity of Water absorbed by Barley. Swell of Grain in Steep. Tests. Days of Steeping. Steep-liquor. Analyses. Salicylic Acid. Pneumatic Steeping.
Couching:—
Undesirability of Couching. Temperatures. Austrian Cold-sweat Couch. Benefits of Low Heat in Couch. Analysis. Gecmen Warm-sweat Couch. Disadvantages of Heat. Pneumatic Couching. Felted Malt.
Flooring.—
Skill of Maltmen on Floors. Turning in Kiln. Objects of Turning. Slippers. Sweeping. Condensation. Length of Root. Times for Turning. Objects of Germination. Friability. Shifting Floors. Chemical Changes produced by Germination. Modification of Starch and Proteins.
Sprinkling:—
Controversy concerning Benefits, Ford, &c. Fraudulent Practices. Dead Couch. Time. F. Faulkner's Views. Continental Practices. Chodounsky's Experiments. Pneumatic-sprinkling. Kiln-sprinkling.
Withering:—
Necessity for Withering Loft. Kiln-withering. Length of Acrospire and Rootlets. Heap-withering. Pneumatic-withering. Friability.

GROWTH causes the distinctive difference between malt and corn. Although they may have passed through all the processes needed to make malt, any kernels which have not grown remain as barley, wheat, or whatever they may be, and *are not malt.*

Until very recently it was almost universally held by all connected with the industry in Great Britain, that malt must be solely *vegetated* grain.

The free manufacture of other materials into malt, independently in any form, of the process of growth, has, however, considerably modified the opinions of many upon this point. Accordingly it is now frequently the case that much grain, entirely unvegetated, is sold and used as malt.

So long, however, as malt is made by the old plan of ordinary growth on floors, the subject of germination will retain its importance.

The first essential of germination is a supply of moisture in adequate and right proportions.

The other requisites are—air, heat, and light.

For malting purposes, it may be urged that light is not essential.

Strictly speaking, this is true, as malting can be (frequently is) conducted in underground vaults or other positions from which daylight is permanently excluded.

To make malt in the best manner, light is certainly desirable, if not absolutely essential.

Air, heat, and water are indispensable.

A great deal of information upon these points has already been set forth. See Chap. V.

The meaning of the term germination has been strictly defined as "a rapid phenomenon marking the entire intermediate period between the embryonic life and the vegetable life of the plant." It is generally admitted that germination terminates when the embryo has exhausted the whole of the stored-up pabulum of the seed. As a maltster never carries growth to this limit, it is needless to determine the true line of demarcation between the germination and vegetation of corn. As the movement of the plumule and putting forth of roots or radicles are regarded by many as vegetative acts, it is necessary to state that for maltsters' purposes they are regarded as essential features of germination, and are here grouped accordingly. In all cases where germination has merged into vegetation, it will still be called by me, in maltsters' parlance, germination solely.

Heat, air (if dry), and light may be applied to seeds or corn for very lengthened periods with no tendency to produce growth, and with very slight damage or influence upon vitality.

Water, air, and light may also be applied, but if the temperature is less than 34° or exceeds 140° Fahr., all future germination is effectually hindered, for the seeds perish.

Water in right degree and proportion without air is also incapable of producing germination, and rapidly kills the germ.

As the main charge of a maltster is properly to germinate his corn, it follows that the bulk of his attention must necessarily be given to the right regulation of the supplies to it of air, heat, light, and water.

The whole art and mystery of malting is embraced in the comprehension of these four conditions.

It is no longer pardonable to term germination—or, indeed, any of the effects attributed to it—fermentation. The processes, causes, and effects are so entirely distinct, and differ so widely from each other, that to speak of germination as fermentation is dangerous and erroneous. So far as existing knowledge extends, it has been clearly taught that, although the influence of germination may resemble in some cases and particulars the influences attributed to zymotic action, the quickening and growth of *any* seed-germ is distinctly and definitely different from the reproduction or development of any yeast or ferment-cell.

How far diastatic action may be attributed to the zymotic action that almost invariably accompanies growth of corn, is a question too novel for an opinion to be even suggested. I have not yet met or heard of anyone who has considered it, excepting in Japan. (Prof. Atkinson.)[*] See Saké Brewing, pp. 172—4.

STEEPING.

It is supposed that the operations of a maltster closely resemble the normal actions of nature in growing grain, or, in other words, that all maltsters try to imitate nature, so far as possible, in every act.

This supposition is true only in a very modified sense, for all men overlook, far too seriously, the difference in access of air to grain out in the soil or immersed in the water of a steeping-cistern and buried in a deep couch, or thick layer of grain, on floor.[†]

Steeping is commonly performed by running the screened barley into the cistern, and after it is all in, submerging it with water.

Industrious individuals expend a certain amount of effort in stirring up this mixture of corn and water, and they remove the "floaters" or "swimmers" and such refuse as may happen to float upon the surface of the water.

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[*] PROF. ATKINSON, The Chemistry of Saké Brewing.

[†] The following extract from the best work on Malting known until very recently, has considerable interest. It is taken from Mr. Ford's Treatise on Malting and Brewing (London, 1862), pp. 72—74.

"The seeds of plants, when placed under certain circumstances, undergo a change called Germination. The result of this change is, that the starch, or fecula, contained by most seeds, receives new qualities; the most predominant of which are an increased degree of sweetness, and a more complete and ready solubility in water of a given temperature. The business of the maltster is to arrange and govern the circumstances necessary to germination; also to obtain these qualities in the highest possible degree. The chief circumstances to be attended to, in order to produce the healthy germination of seeds, are:—

"First.—The adjustment of the temperature, which should always be above the freezing point, and below a mean of 60° Fahr.

"Second.—The regulation of a supply of moisture to the seed.

"Third.—The regulation of the access of air to the seed.

"The *conjoined* operation of these three agents—atmospheric air, heat, and moisture—in given degrees, is requisite to germination, for seed will not germinate without air, though moisture be present; nor without moisture, though air; nor without the requisite degree of heat, though both air and moisture be present. Seeds never vegetate when exposed to a temperature below the freezing point; nor when buried too deep in the soil to admit the action of the atmospheric air upon them.

"When seed is placed under a favourable arrangement of these circumstances, the growth proceeds; and the following leading phenomena are observed. First, the husk or membrane which envelopes the component parts of the seed is swollen and bursts; the plumula, called by maltsters the acrospire, the part that produces the stem and the leaves, gradually expands, and when *buried* rises to the surface of the soil; the radicle puts forth ramifications, and becomes a root. These changes constitute what is understood by germination in the extended signification of the term. The cotyledon (or the part of the seed which contains the matter for the early nutrition of the young plant), which is originally insipid and farinaceous, becomes sweet and mucilaginous, and furnishes materials for the

Unless very urgent reasons for this practice exist, it should not be followed, for in every case it is preferable to fill the cistern with water prior to running in the grain; then the corn should be slowly discharged into the cistern and kept stirred during the whole time of its descent, unless it is passed through a washing machine.*

By this method a great deal of dust and refuse of many kinds is at once removed, and its power to produce further evil prevented.

I have not yet encountered three maltsters in Britain who take the trouble to ascertain the true temperature of the steep-liquor at any part of the process. Yet this is an important point. Many experiments have been made to determine the influence of heat in cisterns upon corn, and it has often been proved that many samples of barley grow very differently if steeped at temperatures differing from each other by only a few degrees.

Thus, a sample of corn, every kernel of which is capable of growing if steeped at 53°, entirely refuses to grow at 34°, and is killed at 140° or less. These temperatures are rarely found in a malt-house, but the variations of heat that are encountered are quite sufficient seriously to imperil the vitality of much corn that is steeped. Many malt-houses are fed directly from small land-springs, or brooks that run past them. In cold weather this water is frequently below 40°. Barley steeped at such a heat has its growth retarded, and if very weakly, it dies. Under no circumstances should the contents of a steeping-cistern ever fall below 50°, or exceed 55°.

Apart from the direct influence heat exerts upon the vitality of the grain, it has been frequently found that a temperature exceeding 56° favours the production of lactic and other acids in the steep.

" early nutriment of the plant before its roots and leaves are adequate to their full " functions.

" When the root and stem have acquired a certain degree of vigour, the cotyledons either rot away or become leaves, and the plant derives its nourishment " from the absorbing power of the root and leaves.

" Now, in malting, the process of germination is allowed to go on to the extent " at which the cotyledon, or insipid farinaceous matter, becomes to the utmost " attainable degree sweet and mucilaginous. The seed is then subjected to a degree " of heat which drives off the moisture, and stops the process of germination.

" The germination of barley, to make malt, is carried usually to the extent when " the plumula or acrospire has elongated, and has nearly reached the opposite " *extremity of the seed;* it is then stopped by heat; the kernel, or farinaceous " matter in the grain has, now that it is dried, become loose and mealy. It is " soluble in water heated to a certain degree, and this solubility is the next " valuable quality communicated; as that malt is the best which yields the greatest " quantity of soluble matter to heated water."

* FORD, Malting and Brewing, p. 91, says: "First of the steep or cistern, a " square or oblong chamber lined with lead or cement. It is usually sunk about one " foot below the level of the floor, but some are elevated three, four, and six feet " above it. It is filled with water to the proper height. At the bottom of the " cistern I recommend a false bottom of cast-iron; it suffers the liquor to drain off " more rapidly, and in the event of the corn being dusty or stale, it cleanses much " better. The drain-cock is outside, situated where most convenient. The dry " grain is let into the cistern, previously filled with water (the thin corn floats, " which I skim off), that it may be saturated with the water necessary to commence " and carry on germination."

In ascertaining the temperature of the water, it is desirable to take it every six or twelve hours, for heat is generated in cisterns. This is accounted for by Wiesner by heat being set free by grain directly it absorbs water, and Sachs asserts that a rise of temperature of 4° or 5° takes place when dry starch is wetted with water at 50° to 60°. It is frequently the case that barley at 50° steeped in water at 49° will in a few hours rise to 53°.

Should the temperature of the liquor be high, it necessitates more frequent renewal and consequent removal of larger quantities of the extractive matter of the corn, for each given volume of warm water extracts more from the grain than an equal volume at a lower temperature, and its frequent removal further augments the harm done.

It is almost always preferable to remove steep-liquor when it becomes only slightly putrescent. Both soft and warm waters naturally allow the colouring and other matters from the husk, and a small percentage of the soluble matters formed during the steeping-process in the grain, to become offensive more readily and rapidly than hard or saline water. In such cases it is desirable to remove the first steep-liquor within the first tide.[*]

In many cases this action is preferable if the renewal is effected by running under the bottom and overflowing, as a greater amount of impurity can by this plan be removed than if the layer of corn is made into a filter-bed.

Very few liquors are of a character to allow of constant inlet and overflow of steep; accordingly, it must be tried with caution,[†] and the question should never be determined by mere empirical rules or "practical experience."

Experience is a very useful staff, but a most pernicious crutch; the veriest idiotcy is daily performed under its protection, and no fetish in Central Africa has firmer devotees. Malting is an industry which has escaped the iron fetters of the law, and it is in the throes of delivery from the adamantine bonds of custom plus experience. Many men cannot be made to see or believe that reliance on mere experience is most pernicious.

To those men who can believe that all natural laws are open to discovery by patient students, I wish to write; and I cannot refrain from expressing the regret that my own knowledge is but the veriest tag in the outer fringe of the great garment of truth that our happier descendants will inherit.

Experience is almost the sole guide to maltsters in Britain as to the right and proper periods for renewal of steep-liquor.

The true factors to be considered are:

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[*] The tide in malting equals twelve hours.

[†] Steel advises this practice in summer time, assigning as a reason the necessity in steeping to keep down temperature. He also advises lengthened and thorough steeping.—Steel, James, Selection of the Principal Points of Malting and Brewing, and Strictures Thereon, for the Use of Brewery Proprietors. (*Glasgow*, 1878), pp. 8, 9.

I.—The character and heat of the water used.
II.—The barley steeped—as to its age, condition, and general nature.
III.—The weather or season.

With so many varying factors, it is obviously difficult to formulate any rule that is capable of universal application.

The colour of the liquor is one of the accepted criteria as to desirability of changing steep-liquor. This, naturally, is ruled by the character and heat of the water and of the corn. The most deleterious influences are probably zymotic. The progress of development of the putrefactive ferment is roughly capable of admeasurement by testing the quantity of lactic and other acids produced or present in the water.

In many cases it is desirable to change the liquor when litmus paper is turned red by immersion in the cistern. The precise tinge it is desirable to avoid is, unfortunately, dependent upon the circumstances or factors indicated.*

Thausing † advises, "in the cold season to renew the water "twice the first day, once a day for each succeeding day, and "twice on the last day." In Bavaria almost all barley is steeped at least three days, and frequently more, for the steeping is considered inadequate if it is not continued sufficiently long to render the grain quite soft.

Very protracted steeping effectually kills a considerable percentage of weakly kernels in almost every sample of corn, and for this reason, if for no other, is to be deprecated. As it, however, invariably means a large loss of extractive matter and a considerable addition to the baneful effects of putrefaction in all its forms, it is obviously wiser to err on the side of undue steeping, due regard, of course, being paid to the right encouragement of vigorous early radicles.

The evils engendered by oversteeping are irremediable, but the defect of insufficient water is readily compensated by sprinkling upon floors.

On the other hand, practice seems to show that insufficiency of steeping is not fully compensated by sprinkling on floors. Ford ‡ is of opinion that this is harmful, and says: "If barley "be insufficiently steeped, the injury cannot in every case be "corrected by sprinkling, because no water applied on the "floor, particularly before the root is formed, can be equally "absorbed; some of the corn gets too much, others not "enough; hence an irregular vegetation."

This question is more fully dealt with under Sprinkling.

When grain is oversteeped, it is necessary, in the first place, to try to bring it in as dry a condition as possible to the floor. This is accomplished by allowing the grain, when finally drained off, to remain longer than usual in the cisterns, provided they have well-drained conical bottoms.

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* Ford says (*op. cit.*, p. 100): "I am fully convinced of the great benefit resulting "from the change of water; it clears and purifies the corn at all seasons, particularly "in mild weather, or when the corn is stale."

† Preparation of Malt, &c., American edition, p. 278.

‡ *Op. cit.* p. 104.

Then care must be taken that the grain on the floor loses as much water as possible by evaporation. This is best accomplished by spreading it out very thinly, whereby a greater proportion of barley-grains is exposed to the direct influence of the air on the growing-floor than if piled in heaps, and the evaporation is likely to be more rapid. The ventilation of the floor also influences the treatment of over-steeped barley. If the ventilation is bad, and damp air is not replaced by dry air, in a short time the air in the floor will be saturated with moisture. Instead of promoting evaporation from the barley, it will have an opposite effect, and should the temperature of the floors be less than that of the atmosphere, the excess of moisture in the air will condense upon the floors. The treatment of the couches must also differ from that of a normal steep. The turning must be effected more vigorously, so that the water draining downward is brought into constant contact with the air, which, if kept dry, carries it off rapidly. As long as the couch remains green, it must be turned more often than usual. Evaporation will thus be greatly promoted, and decrease in temperature inevitably follows, so that germination will be prevented from making too rapid progress. The later treatment of such barley must be governed by its nature, and probably it is never advisable to carry it on in a warm sweat, as thereby too much loss occurs.

In Bohemia a practice is adopted (which is approved by Dr. Graham *) of steeping for twenty to twenty-four hours in a cistern, and then couching at a depth of about ten to twelve inches. The corn remains in this couch for another twenty-four hours, when it is returned to the steeping-cistern and is again submerged. Should the after-steep be a protracted one, care is usually taken to change the second steep-liquor frequently, but very generally it lasts only for about eight to ten hours, and the liquor is changed twice, or is kept constantly running.

Some Continental maltsters have adopted the practice of subjecting the corn to a constant shower of fine water-spray. The plan has been found practicable, and theoretically it has much to commend it. The corn can absorb as much moisture as the germ requires, at little loss of extractive and soluble matters, and the grain is subject to the beneficial contact of air throughout the whole period of saturation.

The practical disadvantages of this method are the greater length of time required and the wide fluctuations of temperature induced by the differences of saturative capacity of the air.

These differences, both of time and degree, do not exceed those that are still found in different parts of Britain at this moment, for in Scotland it is not unusual to meet maltsters who give 112 to 120 hours in steep, and who use liquor at a temperature slightly over the freezing point. I have even met maltsters in the south and west of England who gave this year (1885) ninety hours in steep to thin Smyrna barley.

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* Cantor Lectures, *Journ. Soc. Arts*, 1874.

Ford says[*] that dry, kindly barley increases most. To make malt most *productive* to brewers he gives kindly barley sixty-five to seventy-two hours in cistern; hard, steely, unkindly, fifty-five hours or more, and sprinkles. He adds that new barley requires a longer steep than old; thin or light barley the shortest time. In no case would he give less than fifty hours.

The quantities of water absorbed during steeping vary according to—

I.—The quality and nature of the barley. (Age and soil are large factors.)
II.—The temperature and character of the water.
III.—Duration of steep.

Thomson[†] states that "the quantity of moisture imbibed " by the barley varies according to the goodness of the barley, " and the length of time it is allowed to remain in the steep. But " the general average may be stated at 0·47; or 100 lbs. of barley, " steeped the usual time, weigh 147 lbs., newly taken out of the " steep and dried."

"Dried," I assume, means simply that the moisture was removed from the surface or skins of the corn. How perfectly this was done is not stated.

The assumed swell of grain in steep during the later years of the collection of the Malt Tax was 18·5 per cent., *i.e.*, 100 bushels of barley measured prior to steeping would give 118½ bushels after a normal steep of 45 to 50 hours.

Ford[‡] gives:

		Per cent.
The rise or swell upon corn steeped	40 hours ...	16
,, ,, ,,	52 ,, ...	18·5
,, ,, ,,	72 ,, ...	21·5

He also says: "The longer corn is kept in steep, the greater the swell by absorption, consequently the higher the charge, and the greater the quantity steeped; or, rather, the greater the depth of the corn, the less the charge is in proportion."

Fortunately we need not be influenced now by considering how to avoid any payment of duty, in arranging either the time of steep or its influence upon the swell of grain. This is now simply a matter of curiosity.

Thausing[§] states: "That 100 parts by weight of barley,

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[*] *Op. cit.* p. 102.

[†] T. THOMSON, Brewing and Distillation (Edinburgh, 1859), p. 18.

[‡] FORD says, *op. cit.* p. 103:—"If gauge of corn in cistern exceeds couch it is " caused by rise of temperature of water caused by negligence in not properly " supplying with cold water. To keep corn in steep too long is injurious, as it " prevents germination at the proper time, thereby exhausting a portion of the " vegetative power. Dr. Ure is of opinion, if oversteeped, it causes an abstraction " of saccharine matter by the water. And if a barley-corn, when strongly pressed " between the fingers and thumb, continues entire in its husk, it is not sufficiently " steeped. If barley be insufficiently steeped, the injury cannot, in every case, be " corrected by sprinkling, because no water applied on the floors, particularly " before the root is formed, can be equally absorbed; some of the corn gets too " much, others not enough, hence an irregular vegetation."

[§] THAUSING, *op. cit.* p. 357.

" which contains 12 per cent. of moisture, gives on an average
" 150-155 parts by weight of steeped barley."

The true quantity of moisture required to fully steep all grain varies so materially that it is not possible to give any rule concerning it.

I have tried to ascertain, by a series of careful experiments, the absorption of water by weight, but no practical benefit or definite result has yet been attained. I believe, however, that this is the right basis to work upon, for a given quantity of the dry substance of barley should absorb a certain quantity of moisture to attain certain results. Prolonged and varied experiments alone will prove if any law exists regulating the most effectual germination of corn by constantly having any certain ratio of water to dry grain.[*]

Germination will begin in grain which has 20 per cent. by weight of water added to it.

Thirty per cent. is sufficient to carry some barleys through the whole of the stages of growth practised in some malt-houses. Other barleys, however, require 40 or even 50 per cent. Consequently it is more than possible that no hard and fast rule capable of ready and invariable adjustment will be formulated for many years.

Formerly most houses steeped only every four days or three times a fortnight. By adopting my system of drying to

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[*] Some experiments of Herrn Behrend and Stürcke, communicated from the Agricultural Academy, Höhenheim, and published in the *Wochenschrift für Bierbrauerei*, Dec., 1884, are worthy of careful consideration.

Three samples of barley were employed, the first Saxon Saal, the second Bohemian, and the third Hungarian. Of each 22 lbs. were steeped in 2¼ galls. of water, in a conical vessel. After fourteen hours' steep the first water was run off and measured, the deficiency in the tin measure indicating the amount of water absorbed by, and adhering superficially to, the grain in the cistern. Ten litres of fresh water were then added to the grain, and at the expiration of twenty-four hours were run off and measured. A third supply was added in like manner, after twenty-four hours' further steeping. The grain in the cistern was then sufficiently steeped. The weight of the grain in an air-dried and a dried state, and the quantities of water taken up, are shown in Table I.

TABLE I.

	Saal Barley.	Bohemian Barley.	Hungarian Barley.
	Grains.	Grains.	Grains.
1,000 corns, dried, weight	619·08	551·63	514·98
1,000 ,, air-dried ,, ...	731·19	652·96	609·22
22 lbs. took up water:—			
	Pints.	Pints.	
1. After fourteen hours' steeping, including water adhering to surface of corns ..	4·93	5·10	4·90
2. After twenty-four hours' further steeping	1·75	1·77	2·03
3. After further twenty-four hours' steeping	1·16	1·16	1·36
Total	7·84	8·03	8·29

The total water absorbed increased with the decrease in weight of substance. The steep-water evaporated at 230° to 239° Fahr., gave a residuum which was old houses, it became desirable to wet every other day. This of course limited the time of steep to, at most, 47 hours. As a consequence, the differences in absorption of moisture by various kinds of barley had to be made up on the growing-floor, and in nearly every case, no matter where the corn grew, sprinkling became a necessity.

The old test of sufficient steeping, by squeezing a kernel between the thumb and finger to see if the skin freely disengages itself, is thus rendered obsolete by the practice of wetting every other day in the same cistern.

In new houses, however, more than one cistern is fixed, and consequently any desired duration of steep may be attained, but it is wise ever to bear in mind that too lengthened steeping is positively harmful.

Old cisterns will generally divide into two easily.

Big barleys require longer time in steep than small kernels: Rough, coarse, harsh corn longer than thin-skinned tender barley: Barleys grown in high latitudes, or upon great altitudes, much longer than barleys of the temperate zone or grown in plains.

Old barley must always be steeped longer than new.

New barley germinates more quickly than old, and gives double the increase. It is, however, unequal in germination if used before sweat in mow, or sweating on kiln. Bere or bigg requires less time than barley. Barley grown on heavy, stiff soil needs more soaking than light-land barleys.

The fundamental object of steeping is to impart to the corn about to be malted a sufficiency of moisture to ensure perfect and regular germination.

weighed, heated to redness, and again weighed. The proportions of organic and inorganic matter were thus determined. The direct results, both in organic and inorganic dry substance, had to be corrected by the amounts originally contained in the steep-water (4·1 grs. of organic and 26 grs. of inorganic substance per gallon). The quantities in grains of dry substance extracted per gallon of steep-water are shown in Table II. (see p. 182).

TABLE II.

	Saal Barley.			Bohemian Barley.			Hungarian Barley.		
	Dry Substance.	Organic.	Inorganic.	Dry Substance.	Organic.	Inorganic.	Dry Substance.	Organic.	Inorganic.
By 1st steep-water	3·825	1·814	2·011	4·340	2·056	2·284	5·930	2·829	3·101
,, 2nd ,, ,,	1·290	0·485	0 705	1·576	0·634	0·942	1·908	1·038	0·870
,, 3rd ,, ,,	0·710	0·511	0·199	0·767	0·488	0·279	0 816	0·541	0·27

These results show that the extractive capacity of the first steep-water is much greater than that of the rest. In the first fourteen hours' steeping, three times as much dry substance was extracted from the grain as in the succeeding twenty-four hours, and five to seven times as much as in the third and last twenty-four hours. From these data the injurious effects of over-prolonged steeping, already recognised on other grounds, may readily be deduced."

Muspratt* says :—" The object of steeping is to expand the " farina of the barley with humidity, and thus make the seed " fit for germination, when subsequently exposed to the " air."

Paul† gives as an object in steeping :—" To remove from the " husks extractive substances which would spoil the taste of " the beer."

There are several signs by means of which it can be determined if the steeping of any particular description of barley be completed.

I.—If a kernel is taken and the two ends are squeezed together between the thumb and finger with comparative ease, enough water has been absorbed. If it squeezes too easily, it is oversteeped. If it is stiff and harsh, it is not steeped enough.

II.—If in squeezing as above, the skin leaves the body of the grain, it is sufficiently steeped.

III.—If a common needle can be readily and easily passed through a grain, it is sufficiently steeped. If the grain is very soft or milky, it is oversteeped.

IV.—When cut with a sharp knife, the whole interior of a kernel should appear equally wetted.

In examining barley in steep, it is necessary to take a number of kernels, and care should be taken to select the smaller and weaklier corns, as well as the big and vigorous kernels. Injured or broken grains absorb water more rapidly than whole kernels, and thin-skinned corn is also more quickly steeped than that possessing thick, harsh skins.

Wheat and rye need less time in cistern than barley. In many cases only half the length of time is required, as most wheat will become sufficiently steeped in twenty-four hours. Both wheat and rye need less time altogether for germinating, so that they require relatively less moisture, apart from their ability to absorb with greater facility.

Oats, also, cannot remain in cistern so long as barley without injury. Good heavy oats can generally absorb sufficient water in forty hours, and, in many cases, in even less time.

The days for steeping, in an ordinary English malt-house, are influenced by a variety of considerations. It is often wished to avoid Sunday-work as much as possible. In this case steeping occurs three times in fourteen days, generally on Monday, Saturday, and Wednesday. By this plan, filling and emptying cisterns on Sunday is avoided, and in a house that enables the loading of kiln to be omitted on the eleventh day, very little kiln-work, also, would require to be done on the Sabbath.

By wetting every two or four days regularly, it is impossible to dispense with Sunday labour.

Steeping every Tuesday morning or Friday night, or every

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* J. S. MUSPRATT.

† B. H. PAUL, Industrial Chemistry (London, 1878), p. 941.

Tuesday, Thursday, and Saturday, gives the minimum of inconvenience, so far as I have yet discovered.

Commonly the days of steeping are ruled by the power of the kiln. Should this be smaller than the rest of the house, and the drying be accomplished in twice loading, then five, six, or even seven days' intervals of steeping occur.

Some very badly constructed houses load the kiln three times with the green malt of one steeping. Generally the wisest thing to do with such kilns is to pull them down, or practically reconstruct them. It is out of the question wishing to make them economise labour, or malt properly.

The qualities of water for steeping, and of steep-liquor, have been already discussed at length in Chap. V., pp. 48, 49, and Chap. XII., pp. 177—182. I shall therefore give, in further elucidation of the subject, only the experiments made at the Brewery School, Munich, by Michel and Jäckel-Handwerck.*

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* A good sample of Auvergne barley was divided into three equal parts, and steeped in the same well-water at equal temperatures; but the period during which the steeping lasted differed. The three samples were malted and kiln-dried with great care, and the screened malts were analysed within a short time. The following are the results:—

	A.	B.	C.
Period of steeping (hours)	82	96	120
Maximum temperature of the couch (Fahr.)	59°	61°	63°
Period of germination (days)	7	7	6
Dry malt yielded extract (per cent.) ..	78·77	81·30	78·79
,, ,, maltose ,, ..	54·63	49·35	51·84
Ratio of maltose to non-maltose in extract	$\frac{1}{0{\cdot}44}$	$\frac{1}{0{\cdot}64}$	$\frac{1}{0{\cdot}52}$

A Bohemian barley, specific gravity of 1·1994, and containing 15·01 per cent. of water, 2·55 ash, and 63·75 extract, was steeped. In Experiment I., 50 grains of barley were steeped in 60 c.c. distilled water; in Experiment II., 60 c.c. water containing 1 per cent. common salt were used; and in Experiment III., 60 c.c. well-water (having 30 grains per gallon of residue on evaporation, of which 8·4 grains were organic matter) were taken. After twenty-five hours, the first steeping-water was replaced in all three experiments by 60 c.c. of the original water used, and this operation repeated after twenty, and again after twenty-nine, hours' steeping. The following tables illustrate the results obtained, calculated on 100 grains barley:—

	First Steeping. Time: 25 hours.			Second Steeping. Time: 20 hours.		
Experiment.	Water absorbed.	Extracted matter. Mineral.	Extracted matter. Organic.	Water absorbed.	Extracted matter. Mineral.	Extracted matter. Organic.
	c.c.	Grains.	Grains.	c.c.	Grains.	Grains.
I.	42	0·129	0·109	13·6	0·070	0·064
II.	38	0·087	0·130	12·8	0·650	0·109
III.	42	0·131	0·121	8·0	0·067	0·077

Thus Lintner says,* "The growth of radicles is impeded by the presence of chloride of sodium (common salt), and the elimination of albuminous matter reduced.

	Hours in Steep.	Days on Floor.	Mashing Extract.	Albuminoids in Malt.
Steeped in ordinary water ..	97	6	69·9°/o	8·85°/o
Do. in water, with addition of 0·03°/o salt ..	125	7	66·3	11·91
Do. do. 005°/o ,, ..	132	9	63·5	12·65

The excessive time of steep is noticeable.

The question of mould in steep is generally disregarded by maltsters, as it commonly escapes detection. Much mischief is very frequently accomplished by the dissemination of mould-spores in cistern, and also by negligent indifference to putridity of steep-liquor, and its consequent acidity.

To prevent such mischief, Jericka advises a small quantity of bisulphite of lime (see p. 48) to be added to all steep-liquor in hot weather and to the first only, in cold.

On the Continent, and to some extent in America, the use of salicylic acid in cistern is approved. The quantity generally used is about one pound of acid to twenty barrels of water. The mode of employment in Germany is as follows:—

After the grain is soaked and well washed, add 1 part of salicylic acid to 5,000–6,000 of water and stir well together. All fungoid growths are very largely prevented by this process. The germs are removed by washing, or killed and rendered incapable of development by the salicylic acid. No taste, or evil of any type arises from this treatment, and mildew or mould in malt, both in the house and store, is almost entirely prevented. The keeping-power of the malt is also very largely augmented.

With barley which is only slightly defective, the symptoms of evil are capable of recognition in the cistern. Sudden and wide fluctuations of temperature, or any marked atmospheric

	Third Steeping. Time: 29 hours.			Total: 74 hours.		
	Water absorbed.	Extracted matter.		Water absorbed.	Extracted matter.	
		Mineral.	Organic.		Mineral.	Organic.
	c.c.	Grains.	Grains.	c.c.	Grains.	Grains.
	8	0·053	0·048	63·6	0·252	0·221
	6	0·324	0·040	56·8	1·061	0·279
	10	0·043	0·043	60·0	0·241	0·231

It was thus found that the addition of salt to the water retards the germinating process.

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* Lehrbuch der Bierbrauerei, p. 137.

change, in many instances favour the development of the evil. A greater tendency is also exhibited to putridity of steep-liquor and consequent increase of acidity. In those cases where the evil is aggravated by too frequent renewal of steep-liquor, the use of salicylic acid or of bisulphite of lime is invaluable.

In pneumatic maltings the intervals of steeping are ruled by the power of the kiln, or the convenience of working.

To attain the best results, it is generally most convenient to steep at five-tide intervals with undeviating regularity. In a properly constructed house, the duration of steep is of course entirely independent of any other circumstance than the requirements of the steeping grain. The entire conditions of the surroundings and steep are as completely and easily controlled as the motions of a well-made clock by a skilled clock-maker.

COUCHING.

After barley is steeped it is placed in couch. So long as the Malt-tax was collected this was a prime necessity, as many penalties were attached to any departure from the orthodox method of throwing or treating grain in couch.

After corn is steeped it requires ready access of oxygen, and free contact of air. It also needs the removal of the carbonic acid gas invariably disengaged.

It is difficult to comprehend how these desiderata were attained in the couch-frame, constructed as specified by numerous Acts of Parliament. It is still more difficult to perceive what benefit accrued from couching, excepting the gain of heat and consequent sweat, especially as one of the highest accomplishments of a practical maltster was to be able to drop steeped-corn into couch with the greatest attainable compactness.

Practically, in many cases, couching is no longer necessary or desirable, and it is quite common to find, if the corn is left to drain thoroughly in the cistern for six or twelve hours, that it answers all ends.

In Germany it is a rule with maltsters to practise this form of couching with great care, as they contend that much harm can readily be done by a want of due regard to drainage and aeration at early stages.

Numerous experiments have proved that the access of heat in couch tends directly to produce acidity in the resulting malt. The temperature of couches varies somewhat widely. The lowest I have ever seen was 40°, and the highest 69° Fahr., although greater extremes of both cold and heat occur in houses carelessly managed.

Ford* says that "while the corn is in couch it seldom, in "malting weather, reaches above two degrees in temperature "above the floor; and in cold weather the difference is more "perceptible than in warm weather." Steel says the same thing. Numerous other writers (Muspratt, Thomson, &c., &c.)

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* *Op. cit.* p. 109.

advise the acquisition of heat by corn in couch to be such as to gain ten degrees above heat of air on floor. All such advice is, however, obviously absurd. The heat of air may vary largely in a few hours. The right temperature in couch varies very slightly, and is ruled by position and character of malt-house and growing-floors, season, temperature of air, size and quality of barley. If the house is exposed, and the weather is severe, it may be necessary to cover the couch with blankets or cloths to retain heat, for it is never good for the temperature of couch to fall greatly. If, on the other hand, the weather is close and warm, the couch can speedily be opened out, and great care is needed to prevent it getting too hot.

In couch, the distinction between the cold and hot system of working has to be determined, for if it is wished to work corn slowly at low temperature, then the couch must be differently managed than if the work is to be done quickly. Three hundred years ago it was criminal to work malt in less than twenty-one days (see p. 9), which indicates very careful working at low temperature, and necessitates greater cost in manufacture.

The prejudice against undue heat in malting continues to the present day, and is evidenced by the almost total cessation of malting during the warmer summer months, and the dislike brewers still express to so-called cuckoo-malts, *i.e.*, malt made in April and May.

In Austria, at this day, corn is malted at low temperatures in underground cellars. Should the steeping-cistern be of the common square brick type, the corn, after emptying, is allowed to drain thoroughly in heap for a period of from ten to twelve hours, or if steeped in a conical steeping-cistern it is allowed to remain and drain there. It is then at once opened out on the floor at a depth of three or four inches, or, in some cases, even less than two inches; when barley is very sodden or oversteeped, this is very beneficial, for free application of air and consequent removal of excess of wet is good for drowned grain. After lying in this thin couch for about one tide, it is gathered together and couched at depths ranging from six to twenty inches. The depth of this couch is ruled by the character of the grain and the temperature of the air. Corn that is properly steeped can necessarily in very cold weather be couched at much greater depth than sodden grain in warm weather. Generally great care is taken to prevent undue evaporation from the top-surface of the couch, and it is levelled with as much accuracy as good maltsters prided themselves in doing in the old tax-paying days in Britain. This couch is rarely left unturned a full tide; very generally it is turned every five or six hours. This operation is also ruled by the wetness of the grain and coldness of the air.

According to the frequency of turning, coldness of the air, and activity of the grain, the germ chits in a period more or less prolonged. Two to three tides is the common time for the first appearance of the tiny white speck that indicates growth.

It is, however, not unusual for five or even six tides (72 hours) to pass prior to this event, if the barley is cold and stubborn, and has been oversteeped.

The time taken to attain this point rules very largely the future working of the floors. If it is prolonged, then the couch is kept thick; if quickly attained, then the couch is opened out freely, and the young floor is kept thin. The extreme depths in floor range from fourteen to two inches.

During this process it is common to find the corn in a state of sweat, especially if the heat is greater in the middle of the couch than on the surface, and the smell of the grain is distinct and pleasant. The quantity and condition of this sweat serves to guide a maltster in the turning of the floor, together with the observation of the temperature. Almost invariably the sweat accompanies a rise of heat, but, in any case, when the heat reaches 60° to 63° it is desirable to turn. At this stage corn rarely receives injury by too frequent turning.

Under favourable conditions, the rootlets now develope with steady vigour, and the acrospire moves slowly and steadily up the back of the grain. The more uniformly, both individually and collectively, these operations occur the better the resulting malt must inevitably be; and in this operation the true skill and dexterity of each maltster are best manifested. Nothing but prolonged practice and intelligently skilful use of the shovel can enable any man to turn truly and thoroughly a floor of green-malt. Much intelligent and painstaking care is also needed to watch the relative development of radicles and acrospires, for by careful turning their length can be almost absolutely controlled, both in each kernel and in the whole floor or piece.

Houses working in this manner almost invariably have their floors sprinkled at such time as may be necessary. This varies largely as to time, manner, and quantity.

In working in this manner, corn can continue slowly growing for twenty or even twenty-four days, but to do this it is necessary to maintain the temperature, on the majority of floors, constantly at a point lower than 50° Fahr.

The benefits of the prolonged cold-working are claimed to be considerable. Ford[*] says that "the conversion into saccharine matter is the most perfect by a cooler and slower vegetation."

Experiments at the Brewing School, Munich, show with some exactitude the benefits of slow and dry vegetation. Very fine Chevalier barley was steeped seventy-two hours, and then divided into three parts, which were germinated separately. A, a moist germination; B, a cold and dry germination; C, still colder and drier. A and B underwent normal growth, but in the case of C the couch was too dry. The three malts were dried at 100° Fahr. for ten hours, and afterwards kiln-dried for a further period of ten hours. Experimental mashes gave the following results, expressed in percentages of the dry malts:—

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[*] *Op. cit.* p. 115.

	A	B	C
Extract	66·27	70·71	69·63
Maltose	46·59	46·86	43·30

The following quantities of sugar pre-existed in the dry malts :—

	A	B	C
Calculated as dextrose, per cent.	1·051	1·198	1·358
„ **maltose** „	1·576	1·783	2·037

In malt-houses working at or above the ground-level, such slow and cold working is rarely possible, but it is exceedingly desirable that English maltsters should learn a number of the lessons that Continental modes and usages can teach.

One very practical objection to this cold system is the very much greater area of growing-floor space it requires, and the large amount of labour needed.

As a contrast to this cold plan, another, termed the warm-sweat process, is largely practised in Bavaria and other parts of Germany.

After steeping, the corn is kept for two or even three days in a comparatively shallow couch of five or six inches, where it is turned at least twice every tide. When chitting begins, the depth of couch is greatly increased (generally doubled), and allowed to gather heat rapidly. It is only turned when the surface becomes dry. After about two days, the depth is constantly increased until the finish, when it is not unusual to find it so much as 24 inches deep, and upwards of 100° in temperature.

This process is naturally very rapid and irregular, and it has nothing to commend it for brewers' uses beyond the economy of labour and space it renders possible. Commonly it is impossible to avoid considerable running together or matting of the rootlets, and the resulting malt is known as "felt-malt." In the spring, barley can be got fit for kiln by this process in four days only from the cistern, growing in that short time radicles of great length, but very thin and weak. Oats will felt even more readily than barley.

For distillers' uses, Brannt* recommends the method of making felted-malt, and he thus describes the process :—

"FELTED-MALT.—Experience has shown that felted-malt " has advantages over the ordinary malt for distilling purposes, " especially when it is to be used in a moist or green state, " and its preparation requires less labour; but, as only few " distilleries have malt-houses adapted for its preparation, its " use is by no means so general as it should be.

" The temperature for felted-malt must be at least 59° Fahr., " and one or two degrees more would, with the moist air of the " malt-house, be still better.

" When the barley is taken from the steep it is piled in a " heap 30 centimetres (11·81 inches) deep, and turned over " with the shovel every six to eight hours until the exterior

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* Practical Treatise on Raw Materials and Distillation, &c., pp. 92—94 [1885].

" of the grain appears entirely dry. When this is accomplished " the barley is allowed to rest until the fibrils of the radicle " commence to show at the tip of the grain; the barley is " then spread out in a heap 10 centimetres (3·93 inches) deep. " This heap is allowed to rest until the radicles have grown " into each other; this is called felting the malt. Should the " upper layer of the heap become too dry before the lower layer " is thoroughly felted, it is advisable to sprinkle some lukewarm water over it before turning the heap.

" The turning of the heap is effected with a sharp, flat, " wooden shovel. The malt is spaded into large square " sections, each section being turned separately. The grains " of malt falling off in spading are either brought into a heap " by themselves or used for filling up the intermediate spaces " caused by turning the heap. How often the malt has to be " turned depends on the degree of felting; the proper period " of turning has arrived when the lower layer has felted " stronger than the upper.

" Felted malt, whether it is to be used in a green state or " converted into air-dried or kiln-dried malt, must be previously " torn apart, which is best done by the use of a machine for " the purpose. The machine is very simple and inexpensive. " An oaken roller about 15 to 20 centimetres (5·9 to 7·87 inches) " in diameter, and 40 to 50 centimetres (15·74 to 19·68 inches) " long, and furnished with wooden or iron axles, rests in " brasses which are fastened to a strong oaken frame, provided " with legs. The roller is studded with sharp, iron spikes " about four centimetres (1·57 inch) long, and moved by means " of a crank. Over the roller, somewhat inclined to the side, " is a hopper, which is fastened to the frame in such a manner " that its lower part almost touches the iron spikes. The top " of the hopper may be as wide as desired, but it must contract " towards the bottom so as to have only a slit 8 to 10 millimetres (0·31 to 0·49 inch) wide. The pieces of felted malt " are thrown into the hopper, and, pressing towards the lower " part, are caught as soon as the roller is set in motion by the " spikes and torn asunder. The malt falls into a box placed " under the machine.

" We have previously stated that it would be advantageous " to use the malt in a green state. As this, however, cannot " be done in most cases, it must receive a certain degree of " drying, and the less it is dried the greater is the danger incident to the presence of the germs of fungi, which in the " course of a little time may produce an extended and dangerous " fungous growth. In order to prevent this, it has been " recommended to soak the barley, right after steeping, and " just before placing it upon the floors, for some time in a " solution of one part of salicylic acid in 6,000 parts of water. " This is said effectually to destroy all fungous growth which " may adhere to the barley and to enable the green-malt to be " stored for some length of time without damage. We do not " counsel a prolonged storage of green-malt, but rather advise,

" where it cannot be used at once, a sufficient degree of drying
" in order to insure its keeping qualities.

" When the germinating process is finished, the grain is
" taken to the drying-floor, where it is exposed to the air in
" layers 3 to 5 centimetres (1·18 to 1·96 inch) deep and turned
" over with rakes six or seven times daily. When the malt
" becomes dry, it is cleared from the rootlets, some of which
" drop off by themselves, while others have to be removed by
" winnowing. For ordinary distillery purposes this drying
" suffices, but if the malt is to be used for brewing beer, or is
" to be kept for a long time, it has to undergo a roasting
" process."

Dr. Graham, in the Cantor Lectures of the Society of Arts, says: " I cannot caution practical maltsters or brewers too
" strongly against the employment of a high temperature, no
" matter whether it be in the malting or fermenting processes.
" As regards this question of temperature of the floors, the
" English are decidedly right and the Bavarians are decidedly
" wrong."

It may be safely laid down as a rule that the germination of the green couch should not be commenced before every imperfectly-dried corn has lost the shininess of moisture, as germination in a warm sweat should be avoided.

It may also be accepted as a rule that, in nearly all circumstances, the heat of couch, no matter what its depth may be, should never fall below 50°, or exceed 65°. The safer limits are 54° and 58°, when sufficient time can be given.

In couches, a variety of odours are detected, which are ruled by numerous conditions of air, water and barley used. The scent that indicates healthful conditions resembles somewhat the characteristic odour of apples. This has been attributed by Mr. Faulkner* to the formation of alcohol in the cells of the grain mingled with carbonic acid gas and mould-spores.

In pneumatic maltings, couching is readily accomplished by leaving the corn in steep prior to running down to germinating-floor, or, if for any reason or convenience of working it is run out of cistern, it can remain for a period on the ground-floor; or, yet again, it can be run at once down to growing-floor and remain for any requisite time with little or no air drawn or driven through it.

As a distinctive operation, couching loses its individuality in a pneumatic-house. For the period corresponding to couching in an old-fashioned malting, the sole consideration requiring regard is the character and final use of the malt made. The conditions requisite to secure such character are entirely under control.

FLOORING.

This is also called spireing. In an ordinary English malthouse the couch is opened out into young or " green-floor." This is an operation requiring not only considerable knowledge to direct, but, unlike all other processes in malting, a good deal of skill and dexterity to perform. As a fact, it is easier to acquire the knack of using a scythe for mowing than the proper use of a broad turning-shovel on floor. For a number of days the rapidly-grown corn has to be frequently turned in a particular manner and left in a perfectly flat, even state. An experienced and skilful maltster will throw corn in front, behind, or on either side of himself to a distance of twelve or more feet, and leave it of one uniform depth in every spot, and perfectly level. At the same time, by a slight twist, he will ensure that the great bulk of the kernels that formerly lay next the floor shall be brought to the surface, and those previously on top sent below. In addition to this, he will so throw the corn as to give it the precise amount of direct aeration or exposure to the air that he deems desirable or necessary.

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* Occasional Notes, *The Brewers' Journal*, 1884, p. 29.

To perform all this rapidly and unerringly, requires obviously lengthened practice and fair intelligence. As the labour of so turning a floor is greater than a slovenly mode of doing it, a considerable degree of pride in working, or of sheer honesty in workmen, is essential.

To attain the best results, it is a frequent practice in large houses to allot particular pieces to certain men, who have the entire working of them without interference or help; whilst in smaller houses, the work of particular individuals is speedily recognised, especially if it is performed in a slovenly or defective manner.

The only other point in a malting where skill in manipulation is at all needed, is turning a kiln-floor. As, however, this is a very objectionable practice, the sooner it is abandoned the better it will be for everyone concerned; but of this, more anon.

In addition to the mere manual skill called forth in turning floors, a very considerable degree of shrewd ability or practical skill is necessary to determine when and how the floors shall be turned. All maltsters may be naturally endowed with this skill, or they may have gained it by practice; still the working of no house I have ever seen is entirely incapable of improvement.

In turning a floor it is commonly desirable to take it in two lifts rather than one—*i.e.*, the shovel should skim the upper half or surface first, and with a second stroke follow on with the under layer. This mode ensures a more complete upturning of the bottom than a simple turn-over.

A maltster during flooring has to control not only the development or growth of the corn germinating, but the very nature of that growth. He has to give air, and secure ventilation, to regulate heat and humidity, to foster the development of the plumules and check the radicles, or *vice versâ*, as the case may be.

Some of this work is, of course, already attained, or influenced, by the time the grain reaches the floors, for the relative growths of acrospire and roots are influenced materially by the duration of steeping and heat of couch. Steel, in his very irritating and blameworthy book,[*] advises very early opening-out of couch with thinning-out on floor to three inches at once and its maintenance for five or six days at a temperature of 50°, for he asserts that a low temperature, with very little turning at first, "are everything" (*sic*).

Nearly all writers on malt-making state that during this period the true art of the maltster comes into play. I think differently. It would be better for maltsters if they had less art and more knowledge, for an intelligent appreciation of the conditions of working and of the requirements of the grain for its fullest modification for brewers' uses, would ensure more satisfactory working in very many cases and a product of greater value.

The objects of turning a floor are threefold—to loosen and aerate the grain, to dissipate the carbonic acid gas invariably present in couch, or on floor when growing, and to regulate temperature, for the bottom, centre, and top of a floor always vary in heat.

In turning, it is desirable to work deftly and neatly, for irregular working, either in picking-up and shovelling the floor, or when depositing it, invariably produces bad results. It is especially desirable to guard against crushing or otherwise injuring the grain with the feet, plough, or shovel.

In many malt-houses it is a strict rule that all men working on floor shall be barefooted or wear list slippers. In turning a floor it is of course always arranged that no trampling upon the turned piece occurs.

When a floor is finished, it is the rule with all good maltsters to sweep up between pieces with scrupulous care, and to turn back the outer edges of each piece sufficiently thickly to ensure, as nearly as possible, uniformity of heat for those edges that might otherwise grow colder from their greater exposure to air.

In this country no attention is paid to keeping the floor a little distance from all walls and ironwork during the earlier stages of growth; but I have seen in many places in Germany, France, and even Italy, considerable attention paid to this point, because of the differences of absorption and condensation of moisture against all such surfaces as walls and columns present.

For about five or six days very frequent turning of the floor is undesirable. The conditions that determine the necessity for turning are the appearances of the corn and rootlets, temperature of floor, and of surrounding air. In many cases it is sufficient to plough the corn, rather than turn it, although Champion[†] says of the use of the plough "that it is but a "temptation for the working maltster to neglect the turning "of his floors or pieces, by which alone the proper form of the

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[*] J. Steel, Selection of the Practical Points of Malting and Brewing, and Strictures Thereon, p. 10.

[†] W. Champion, The Maltsters' Guide, pp. 43, 44.

" root can be acquired, the proper degree of heat retained, and " the process of germination for the obtaining the most valuable " properties of the malt."

Right turning and ploughing of the corn upon floor, coupled with suitable temperature, air-supply, and humidity, ensure proper germination. For practical purposes, right germination is generally sufficiently indicated by the appearance of the roots and the progress of the acrospire up the back of the grain.

Directly the grain has received a certain percentage of moisture, the germ becomes affected, and germination or growth may be said to begin. One would naturally suppose that the development of germ and radicles bore a direct relation to each other, but in practice it is found that this is not the case. By modifications of air-supply, heat, and moisture, the germ can be induced to grow more rapidly than the roots, or *vice versâ*. Undue development of germ, relatively to roots, is a defect that manifests itself unpleasantly when the malt is brewed, as it interferes directly with the right sustenance of the yeast-cells.

Great length of root with slow progress of acrospire is also a source of direct loss, and must be prevented. It is generally indicative of too high a temperature upon floors.

High temperature, which is the result of warm weather or thickness of floor, is usually better controlled by thinning than by too frequent turning.

It is difficult to turn or handle malt on young floors in any way without injuring or breaking off the tender radicles; therefore no unnecessary turning should occur. But it is better in practice to err on the side of too frequent moving than to leave the corn untouched upon floors for very lengthened intervals.

The times for turning are so essentially ruled or influenced by the nature and quality of the grain, the position and circumstances of the house, and the state of the weather, that it is simply dangerous to formulate any rule as to turning. That is one phase of the business best learnt practically.

Commonly, in Great Britain, the practice of couching is still resorted to; consequently the steeped grain lies in couch undisturbed for twenty to twenty-four hours. It is then opened out and thinned to depths varying from 12 to 2½ in., the depth being ruled by the surrounding conditions. The broken couch is then left, as a young floor, for varying periods. This young piece may generally be left for twenty to twenty-four hours, and be then turned. For the succeeding two or three days it may be ploughed or turned once or twice a-day, or if necessary three or even four times daily. As a rule, however, twice suffices, and is sometimes too much. If the weather is really cold, turning at first must be very carefully done. Movement of the grain is essential, but severe checking or reduction of temperature is very baneful.

The main object to attain is a short, abundant bushy root, with five or six radicles to each kernel, and a regular development of germ. If, at any period from the third to the seventh day, the temperature of the floor is higher than the particular class of barley being malted can support, considerable and irreparable injury is effected, for the radicles flag and droop so seriously, that in many cases, if the injury is decided, they drop away entirely. Practically this is found to induce hardness and steeliness.

The appearance of the roots furnishes a very sure and easily-identified criterion of the rightness of the temperatures and conditions of the growing-floor.

The total time barley germinates upon floors is very varied. The main factors ruling this time are—the barley itself, the weather, the malt-house, and the method of malting. It is unusual for the total time occupied to be less than eight days, or to exceed twenty-four days, when malt is made for brewers' use. When made for distillation it is sometimes carried through in less time even than eight days; whilst malt made for roasting purposes used to be, and in some cases is still, hurried through in from four to five days.

At one time great tenderness or friability of malt was aimed at very strenuously. This is necessarily influenced by the mode of growth. As, however, it is a delusive quality and unnecessary, all efforts made to secure it are a waste of energy, *i.e.*, the friability resulting from special treatment on floor, apart from the tenderness secured in kiln-drying.

In many malt-houses the vegetating corn is carried or dropped from one floor to another. This consequently gives a severe check to growth, if carelessly or improperly done, and, in many cases, results in much damage to corns that are trodden upon or cut with shovels, baskets, &c. It is generally desirable to make changes of this kind, when practicable, on the fifth or sixth day, when, commonly, sprinkling revivifies the grain.

If on taking a handful of grain from the floor it smells faint, and the skin is glossy or wet, it requires turning. After this it will smell fresh, and the grain, instead of being glossy, will be dry. If the turning is omitted at the proper time, the rootlets will be of unequal length and the growth of acrospire will also be irregular.

The odour of properly growing barley when it has a good supply of oxygen and the carbonic-acid gas is freely removed, resembles that of freshly-cut cucumbers. When the smell is like that of apples, it is evidence of imperfect aeration.

It is almost always desirable to wet the spaces of floors between pieces at least twice a day. If any tendency to mould exists in floor, bisulphite of lime should be added to the water so used. (See pp. 46—48.)

In a well-ordered house it is the rule to keep a broom on each side of every piece should any traffic over pieces occur. The mixing of pieces by careless trampling is objectionable.

No steeping-cistern, growing-floor, or kiln-floor, should be without its own special thermometer. Malting by rule-of-thumb only is precisely as ridiculous as mashing by the original method of estimation of heat by seeing one's face reflected in the water standing in the tun.

Thin, foreign or inferior corn may usually be worked at higher temperatures than fine, heavy corn.

Jericka says:—"Every heap should be allowed time for " complete softening-up. It is better in spotted or mottled " barley to close the eyes to a little over-growth of the acro- " spire. The more the barley is spotted, the greater length " may the spire be allowed to attain."

Matting, or balling on floors, must on no account be permitted under any circumstances in malt made for brewing.

Careful perusal of the chemical Chapters IX. and XII. will enable a maltster to find satisfactory and scientific reasons for a number of the conclusions and rules laid down throughout this book, and for the empirical rules resulting from practical knowledge and working.

Maltsters all know that air is necessary for the growing grain. That it is so is readily proved by placing vigorously-growing corn in a close-stoppered bottle. Directly the oxygen present is consumed, all further growth is arrested.

In the germination of barley, we know that carbonic-acid is generated and oxygen is absorbed. Analysis shows that some of the carbohydrates and albuminoids are oxidised and changed, or degraded. Speaking of this, Dr. Graham, in the " Cantor Lectures," 1874, said that " a number of products so " formed are not yet known to chemists; some of them are " intermediate products, having, apparently, the power to " build up, while others have simply the power to break " down. A portion of the albuminous matter is completely " burnt, and the albumen of the barley actually supplies " a portion of the carbonic acid." The whole subject of the chemical changes in barley during germination, has been very much more carefully and elaborately studied abroad than in England. Accordingly we find, on glancing at the Bibliography (Chap. XXII.), a far greater number of writers upon this subject in nearly all other beer-drinking countries than in this.

The modifications of the carbohydrates and proteins of barley by the process of malting, have been briefly dealt with in Chapters IX. and XII. The chief changes are:—

1. Conversion of insoluble starch to amidin.
2. Conversion of proteins into amides.
3. Loss by respiration and by development of rootlets.

1.—MODIFICATION OF STARCH.

This involves neither access or loss of matter, the amidin being of the same empirical composition as the original starch. Some of the granules, however, are destroyed, being converted into glucose and carried into the rootlets in solution, there to be oxidised into carbonic-acid gas and water.

2.—MODIFICATIONS OF PROTEINS.

A general survey of what has been published on the subject of protein-transformations during germination will show that most of the researches relate to the germination of the more highly-nitrogenous seeds of beans, peas, castor-oil plant, lupines, pumpkins, etc. It is obvious that in seeds which are very rich in nitrogen, the transformations of nitrogenous substances play a relatively larger part, and are easier to determine by means of careful analyses. We may conclude that grain containing analogous albumenoids elaborate similar transformations in the processes of germination; but, nevertheless, it is of great importance to have exact numerical data of the relative proportions of such protein-transformations in different seeds during the successive stages of germination. Of all commonly cultivated plants, barley, beyond doubt, is that which presents most practical interest in respect of germination, and by comparison with its importance, the researches into the chemistry of the subject, so far at least as concerns protein-transformations, appear hitherto to have been neither sufficiently numerous nor exhaustive. A large series of valuable researches respecting nitrogen-transformations in malting already exists.[*] But partly, inasmuch as the bulk of these researches deal with the differences in total nitrogen between the barley and the dry malt, and partly as the methods of analysis employed have not been sufficiently minute, it appears very desirable that the protein-transformations occurring in barley during the process of germination should be followed by further analysis.

One of the principal purposes of malting is the formation of diastase. Now, although diastase has not yet been obtained in a pure state, enough is known about it to lead to the assumption that it is a substance approximating very closely to albuminoids soluble in water. And this assumption has been further confirmed since C. Lintner, jun., showed how direct is the proportion between the diastatic powers of a malt and the amount of soluble albuminoid therein contained.[†] Whence it follows that, at least in normal barleys, the proportion of soluble proteids is an indication of diastatic power.

As this power is augmented materially by slow growth upon the floors, Dr. Bersch recommends that the temperature should not be allowed to exceed 63°, or fall much below 59° Fahr. Haberlandt found 77° to be the temperature favouring the most vigorous growth in wheat, barley, rye, and oats, but the diastatic power is considerably diminished by such a heat, and evils are engendered of a kind already described.

3.—LOSS BY RESPIRATION AND GROWTH OF COMBES.

The researches of Mr. T. C. Day, referred to on p. 137, indicate the combustion of glucose derived from the modification of starch in the respiration of the growing malt. Possibly, also, the cellulose and proteins contribute in some measure to the carbonic acid gas and water produced. The combes carry off a considerable proportion both of mineral constituents and nitrogenous matter, as is shown by their composition. Any undue stimulation of growth tends, consequently, to detrimental loss in all the compounds present in malt. The relative amounts of the several substances in the original grain probably affect the relative loss, and in some corn the loss of even a considerable proportion of nitrogenous matter is advantageous, provided it be not accompanied with too great a diminution of the carbohydrates and mineral ingredients. The latter, however, are so closely related to the proteids that excess or defect occurs in both, *pari passu*.

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[*] See Bibliography.

[†] *Wochenschrift fur Brauerei*, 1884, p. 34.

The operation of sprinkling during germination has occasioned an enormous amount of controversy for several generations. The basis of the controversy rested in the legal restrictions of the Act, but many men grew to think the Act itself detrimental to malt, while beneficial to maltsters.

The numerous absurd regulations restricting sprinkling have had the effect of making it a practice little understood in the United Kingdom, and it is consequently a proceeding which is much more fully known and appreciated in other countries.

Notwithstanding the little scope allowed by law, some advanced maltsters have tried every means in their power to obtain liberty to sprinkle, and, as far as possible, tested the benefit of the practice.[*]

In the earlier part of this century maltsters were divided in opinion as to these benefits, some being in its favour, others against it. The large brewers of London who bought malt were unanimously of opinion that the malt that was sprinkled was very inferior. Those brewers, however, who were maltsters, were strongly in favour of sprinkling, asserting that, under certain circumstances, it was highly requisite.[†]

It is well to bear in mind that at this time (1806) the duty amounted to 34s. 8d. per quarter, and sprinkling was not permitted until the twelfth day. This time was gradually reduced, until, in 1860,[‡] it was finally altered, and the limit fixed was reduced to 96 hours, provided the corn had been steeped for 50 hours.

Mr. Ford[§] says:—"I am of opinion, considering the high
" duty of malt . . . . . the fifth day is the extent of indulgence
" which can consistently be asked. Experience proves earlier
" sprinkling is not required. If the corn has received its
" proper proportion of steep in cistern, the corn or grain can be
" effectually regulated by judicious sprinkling in malting
" either free or close malt; but if it be a question of quality, I
" have always found that the long steep, say from 65 to 72

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[*] For much valuable information on the subject, see Ford's Malting and Brewing, Reynoldson on Malt, and numerous Reports ordered by the House of Commons.

[†] Mr. Haddon, Evidence before Committee of House of Commons, 1806.

[‡] 23 & 24 Vict. c. 113.

[§] FORD, Malting and Brewing, ed. ii. p. 38 [1862].

" hours, produces the most even and perfect vegetation, giving " more weight, and at the same time equal flavour and " tenderness."

In two experimental steeps,[*] conducted exclusively to determine practically the value of sprinkling so far as the quality of malt was concerned, the result was that the sprinkled malt weighed 2 lbs. per quarter less, and yielded 2 lbs. less extract when brewed, but paid a duty of 21s. 6d. per quarter (on barley steeped), whilst the unsprinkled malt, steeped for 72 hours, paid 23s. per quarter duty. The yield being 2 lbs. greater, and the extract being valued at that time 9d. per lb., the difference in value was unappreciable, judged roughly from this standpoint only, but it centred in the saving in duty alone. Consequently, if we may accept the deductions of Mr. Ford, sprinkling would now result in a loss, as the duty can no longer influence the question, and the unsprinkled malt yielded more by 2 lbs. per quarter. "Loss of moisture (Ford) may " be supplied by sprinkling; the corn cannot by any possibility " take in this moisture so evenly as in the cistern. . . . *Never* " sprinkle until the roots are well developed and sprinkle at " from fourth to sixth day." Champion advises sprinkling[†] very strongly, and gives many weighty reasons for its adoption. He (Champion) recommends three pints of water per bushel of fine bold barley, and is particular in his instructions to mix this water evenly. To do this, half should be added early in the morning and the malt turned at once; then the remaining moiety two hours later, with a second turning. In mild weather three or four turnings should be given the first day. The time for sprinkling is from the fourth to the ninth days.

Ford says[‡] "that what water is given upon the floors should " be given, in *all cases*, before the eighth day; in most cases " what is given should be given on the fifth day."

The practice of sprinkling[§] permitted numerous frauds to be practised which were difficult, if not impossible, without it. As already stated, the frauds against the revenue no longer concern us. The fraud against brewers, of outrunning acrospire to obtain inordinate increase, is one which can be stopped by them. They should not buy such malts.

The most common practice was termed "gelding the cistern," which was done in this way. After about twenty hours' steeping, a quantity of corn would be removed from cistern, and mixed with the youngest floor. The deficiency in cistern would be made good by adding a similar quantity of dry barley to the cistern. Obviously this practice could not be adopted if sprinkling was forbidden for ten to twelve days. When it was possible to sprinkle early, artful maltsters paid, in some cases, little more than half duty. Another practice

[*] Ford, Malting and Brewing, 1862, pp. 129—132.

[†] W. Champion, The Maltster's Guide, 1832, p. 60.

[‡] Ford, *Op. cit.* p. 130.

[§] Steel, in his costly treatise, omits all reference to sprinkling, but nearly all the older writers devote much space to the controversy perpetually raging concerning its value.

was to run whole wettings by steeping for twenty hours, carrying forward at once to young-floor and refilling cistern. Officers of Excise must have been singularly careless or ignorant not to detect this at once.

Honest men did not resort to any such practices, and many of them found that certain barleys were much benefited by sprinkling on the fifth day or afterwards. Very steely or rough, coarse grain from stiff clay soils, quite frequently in bad seasons became languid during early growth, and a right amount of sprinkling was very desirable for it. When this could not be given (from 1827 to 1860), the corn was put into "dead couch," *i.e.*, it was kept on the growing-floors from the sixth to the twelfth day practically unturned, or turned at most once in two days.

Brewers who malt for their own use, very commonly begin to sprinkle on the fourth or fifth day, and continue watering for two days only, using from three to six gallons of water per quarter. The quantity so used necessarily depends upon the grain itself and the state of the atmosphere. It is rarely desirable to sprinkle so late as the eighth day, unless the piece is extremely backward, for grain saturated so late during growth as the eighth day must necessarily wither imperfectly, and carry forward an excess of moisture to the kiln.

Mr. F. Faulkner[*] writes about sprinkling in the following very able manner:—

" The maltster so works as to bring the somewhat erratic " rootlet under control—*i.e.*, if he desires to work for rootlet " he sprinkles before it is so controlled; if, on the other " hand, he wishes to make up sound and good material, he " waits until the energy of rootlet-growth is fairly mastered, " and in this sense the immense benefit of long steep-periods " is apparent, so that sprinkling stage can be delayed till the " fifth day. After this time, sprinkling-water, carefully applied, " goes to encourage growth of back or acrospire, as distinct " from growth of rootlet; and I especially impress this point " as one of increasing importance. I am no advocate of " sprinkling as a substitute for steeping, but only as an aid " to vegetation. In the old days it was generally done from " an economical point of view, but is now unnecessary, unless " the grain require it. Malting-floors are often carelessly " laid, and in the hollows so formed sprinkling liquor is apt to " accumulate, over-saturating such grain as lies there, this " grain frequently over-shooting. Besides this, saturation by " sprinkling is very irregular, no matter what care is expended " when using the can, and in after-turning of grain. My " advice is, that maltsters should adopt the long-steep idea " as far as possible, keeping the sprinkling to within three to " five gallons per quarter. Now, as we utilise moisture for " attaining complete growth, we have, of course, to see that " it is not applied in excess, and my meaning, when speaking " of the art of the maltster, is that in so regulating aeration,

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[*] *Brewers' Journal*, 1884, pp. 28, 29.

" temperature, and moisture, he attains the necessary growth " by the time that the essential moisture has been dissipated " by evaporation. Now, as the frequent turning to regulate " temperature leads to rapid evaporation, the degree depending, " of course, also upon temperature and humidity of atmo- " sphere, the addition by sprinkling necessarily varies. The " careful maltster so adds it that overgrowth is prevented, " while the grain naturally withers (which means vitality again " becoming inert) by the time that the extension of acrospire " proves perfection of modification."

As I before stated, many of the best Continental maltsters pay strict attention to sprinkling, or, as they graphically express it, "after-steeping." This one word truly describes the process, and is in itself sufficient explanation of, and justification for it. With them, however, very great attention is paid to the actual requirements of each particular sample of grain being made into malt. Because one parcel of barley carries two gallons per quarter one day, they do not continue to give every other lot the same quantity throughout the season, and at all times of the season. They study the needs of each floor, and sprinkle according to those needs.

A series of carefully-conducted experiments were published in 1881 in the Allgemeine Zeitschrift für Bierbrauerei und Malzfabrication, which were conducted by Herr C. Chodounsky, to determine the influences of curtailing the steep and making up for it by increased sprinkling on floors.

The results are shown by the following tables :—

Ordinary Steeping. 56 Hours at 45° Fahr. Turned 15 times.				Floored after 30 Hours' Steeping. Turned 22 times.		
Days.	Barley.	Appearance of Germ.	Malt.	Barley.	Appearance of Germ.	Malt.
2	100	—	—	100	—	—
3	100	—	—	Preliminary steeping, 46·6	53·4	—
4	37·3	62·7	—	Sprinkling, 32·6	67·4	—
5	3·0	27·0	70	6·8	29·0	64·2
6	2·8	7·2	90	2·4	10·8	86·8
8	2·6	4·0	93·7			
				2·0	2·0	96·6

Remarks.—The sprinkling was effected with 48 gallons of water at 45° Fahr. to 10 quarters of grain.

In winter there were required, on an average, 36 gallons of water daily, or 24 to 30 cans (72 to 90 gallons) of water altogether up to the commencement of germination for every 17 qrs. of barley. By the ordinary method the same grain would take 96 to 100, steeping at 32° Fahr.

The plumule attained the necessary length with a shorter growth of radicle. As regards loss in malting, the annexed table shows the results so far as observed :—

Mode of Steeping.	Year.	Average wt. per bushel. Barley.	Weight per bushel. Malt.	Loss in Malting.	Combes.
		lbs.	lbs.	Per cent.	Per cent.
Ordinary	1877	54·45	45·43	22·93	4·76
Do.	1878	54·86	46·26	23·80	4·31
Do.	1879	54·74 54·77	44·50	22·52 22·56	4·95 5·67
Do.	1880	54·45	43·68	22·86	4·74
Sprinkling	1880	54·45	45·65	20·97	4·21
Do.	1881	54·45	45·43	21·41	4·24
Average of four years by ordinary method	—	54·45	45·65	23.02	4·67 to 4·79

Carefully-dressed barley was steeped for the space of forty to fifty-two hours in winter, and twenty-four to thirty hours in warmer and milder weather. The steep-waters were run off in the usual way: the first in the course of six to eight hours; the second in twelve to sixteen hours; the third after twenty-four to thirty hours' steeping of the grain. The steeped grain was loaded to a depth of nine to twelve inches on the floors, and spread out more thinly at each successive turning. The floors were turned every five to six hours, the grain being sprinkled with the help of ordinary watering-pots fitted with roses, until moistened to the requisite degree.

In the course of these comparative trials, Herr Chodounsky arrived at the following conclusions:—

1. That barley which has been left but a short time in steep retains a fresh wholesome odour, quite distinct from the common steep-cistern smell, which is a product of putrefactive or acid fermentation.

2. That the uniform moistening with the water-cans and the frequent turning of the grain, whereby it is brought into perfect contact with the air, are favourable to healthy germination.

This is evident by the very uniform germination appearing on the third day with the floors at a temperature of 49° to 53° Fahr., and the equally uniform formation of young malt twenty-four hours later, while the malt on the floors, up to the end of the germinating process, emits the peculiar cucumber-like odour so acceptable to the maltster. Maltsters know well that when malt has been badly managed on the floors, or has been made from unsound grain, it is at this juncture that it betrays the defect by giving out a musty, mouldy, or sour smell.

3. Owing to the curtailment of the steeping, the malt exhibits a fresh amber tone, unlike the greenish tinge acquired in the ordinary process.

4. The grains of malt appear plumper and looser in texture.

5. The sprinkling process renders it possible to malt in the warmer months (May and September), as the water used for sprinkling can be cooled with ice. This produces a certain amount of slight refrigeration on the floors.

The windows of the maltings in which the above experiments were made, were simply screened by ordinary linen blinds, so as to temper the light on the floors.

Bearing in mind the fact that the chief aim of the maltster is to maintain, as closely as possible, the conditions most favourable to the right development of the acrospire and radicles of the germinating grain, I fail to see how sprinkling can be regarded as an evil practice, or even an unnecessary one, in the case of the great bulk of the barley malted. As a fact, I have yet to see any barley whatever which is not benefited by judicious sprinkling, combined with right steeping, when grown on an ordinary exposed English malting-floor.

In sprinkling, care is required at all times not to flood a weakly or struggling floor, and proper turning of the grain is essential.

In pneumatic maltings, sprinkling should be unknown and unnecessary. The air supplied should ever have its humidity so controlled as to keep the grain sufficiently moistened for all its requirements, unless a little top-wetting is necessary.

Other forms of sprinkling which are greatly to be deprecated, are the addition of water after withering, prior to loading on kiln, in order to give the dried malt a bold appearance, or, still worse, sprinkling the malt when dried and freshly thrown off the kiln.

WITHERING.

When barley has its acrospire developed about three-fourths up the back, and has thrown out a good cluster of short, bushy radicles, it has sufficiently grown to be finished off.

In many malt-houses it is simply taken at this stage to the kiln, especially if it has also acquired the cretaceous friability that is indicative of sufficient germination.

Other and more careful maltsters subject it to a regular process of withering with eminently satisfactory results. It is not positively necessary to make malt tender, but it is desirable, and it is necessary to ensure the full effects of germination upon the whole of the constituents of the grain. Proper withering commands friability, and it aids the whole of the necessary modifications of the grain.

Consequently all maltsters should carefully consider the true position and influences of withering, and in all cases where the requisite characteristics of the malt made require it, they should adopt the process.

The true functions of withering are to arrest, or even stop, growth, to dissipate moisture, slowly to acquire warmth, and especially to effect those subtle changes upon the endosperm, and probably the whole of the constituents of the grain, which are very difficult at present accurately to define, but the specific and commercial value of which is very great.

In many malt-houses, especially older ones, a proper withering-loft is provided and used. Practice alone taught our fathers that entire disintegration of the germinating grain was beneficial in the open infusion-system of mashing. This they attained by careful working on floor, and very complete withering, prior to loading on kiln, or during the earlier stages of drying.

In the comparatively fine kilns of the present day, a large proportion of the total benefits of withering are attained by the temperature and nature of the draught in kiln, for maintenance of green malt in kiln at or under 105° Fahr. is accounted an equivalent to withering, and does not finally arrest vegetation.

During the withering stage, whether it occur on floors, withering-loft, or kiln, the momentous question of length of spire is practically determined.

Experience has taught that malt which has the back well up, but not entirely out, gives generally the best results in brewing. Attentive study of the chemical changes effected in barleys by malting, conclusively points to the soundness of the observation that led men to determine the result or effect, long before they had ascertained the cause. The finite influences upon the carbohydrates and soluble albuminoids of grain are fortunately very clearly indicated by the degree of development of the embryo plant — consequently we find maltsters in Britain ruling their conduct by the length of the acrospire. In Belgium, Germany, and other Continental countries, they pay more attention to the appearance and length of the radicles. In this respect it is fair to assume that they are apt to be frequently misled, for although it is apparently the fact that the acrospire indicates accurately the extent and amount of the molecular changes on the grain, the length and amount of radicles indicate chiefly the conditions under which they have developed, and they furnish but meagre criteria as to the fitness of the green malt.

During the later stages of flooring and withering the rootlets wither and dry up, becoming very shrivelled and almost brown, especially if sprinkling be not continued for undue length of time.

In addition to withering, some maltsters throw the oldest floor, before loading in kiln, into a heap, and allow it to gain heat spontaneously, with the object of making it tender. Many eminent maltsters have practised this heap-withering, and still continue to do so—notwithstanding many others assert that it is a pernicious and undesirable plan. Champion wrote very strongly against the practice in 1832, and in Scotland it has become almost obsolete, although in the early part of this century it was nearly universal in that country.

A defect of most pneumatic systems up to the present time is that the inventors, being usually foreigners and unacquainted with the advantages English malt gains from withering, make no provision for this desirable practice. To a brewer using malt on the infusion, or ordinary English mashing system, it is necessary that malt be properly-withered previous to being kiln-dried. With a slowly-decreasing amount of moisture remaining in green malt during its later time upon the floors, a modification of the constituents of the barley occurs that has not at present been obtained by other means. The consequent friability is stated to be a necessity in old-fashioned ordinary open mash-tuns. By sprinkling late on the floors, and removing the moisture too rapidly, a degree of hardness or "steeliness" is obtained that occasions diminished extract and unsatisfactory wort.

All this, however, is not yet proved, for users of pneumatic malt find that friability is not an important essential at all. This malt is made under conditions that enable it to retain all the moisture it requires for growth, and it can go to kiln quite saturated or soapy. It is not mealy when loaded, and often it is the reverse of tender when finished off. It gives, however, equally good extracts with tender malt of corresponding grade.

Hence, although friable malt, grown in the common way, may be preferable, pneumatic malt grown under totally differing conditions is not necessarily inferior in consequence of its deficiency in this particular.

NOTE.—For Summary of Heats see page 389.

CHAPTER XX.

DRYING.

Drying:—
Fitness of Green-malt for Kiln. Excess of Proteins. Reasons why Drying is Beneficial. Three Rules for Drying. Qualities of a good Kiln. Opinions on Drying of Champion, Shannon, Combrune, Ford, and Cermak. Influences of Air. Heats Recommended by Chodounsky and Dr. Graham. Yeast.

First Rule: Depth of Load not exceeding 8 inches:—
Reasons for Rule. Moisture. Turning. Heats. Acids. Cooking.

Second Rule: Malt Unturned:—
Evils of Turning Malt. Origin of Stopes' System. Graham's Cantor Lectures. Stead's Patent. Tamplin's Kiln. Modes of Working. Four Days on Kiln. Heats. Sweating. Opinions of Turning: Black, Ford, and Steiner. Mechanical Turner. Finishing. Necessity for Turning in Single-floor Kilns. Differences in Heat.

Third Rule: Heat must be maintained at Finishing:—
Rules for Drying. Heats. Uniformity. Tables of Heats. Free's Kiln. Wells, Burton, Luton, and Poole Kilns. Advantages of Double Kilns. Mechanical Regulators. Heaping on Kiln-floor. Sudden Heating of Green-malt. Muspratt, Michel, and Marx. Rapid Drying. Dr. Graham's Experiments. Empyreumatic Flavours. Influence of High Heats. Graham's Analysis. Kjeldahl's Researches.

Redrying:—
Steel, Faulkner. Lager-beer Malt. Bavarian, Bohemian, and Austrian modes of Drying. Directions for Use of Stopes' Kilns. Diagrams of Heats. Table of Heats given by Twelve Authors.

THE processes of germination, and their attendant needs, succeed in inducing the material changes in corn that convert it into malt.

By the time barley reaches the end of the withering stage it is no longer barley, but, to all intents and purposes, malt. For distillation, or the production of Weiss beer, it is ready for immediate use if desired, and, so far as its converting or diastatic capacity is concerned, it has at this stage nearly attained its maximum of energy.

For the best production of ales, stout, porter, and whiskey, and for numerous other uses, it is absolutely necessary to subject green-malt to the direct influence of heat, for drying is a vital necessity.

The precise moment when drying should commence can only be determined by the character and condition of the particular bulk of green-malt about to be dried, for it is an impossibility to pre-determine the growth of any sample of corn.

Withered green-malt, fit for the kiln, has the following recognisable characteristics:—

The endosperm is soft, dry, mealy, and very white. It is termed cretaceous or chalky, and, when pressed between the thumb-nails, exudes no moisture, and crumbles or disintegrates without a pasty or dough-like adhesiveness. The acrospire should be in all grains of the same floor, as evenly as possible about three-fourths up the back of the kernel. The roots should be short, curly, and almost dried, not exceeding half an inch in length, or, preferably, one and one-third the length of the kernel. Comparatively slight regard may, however, be paid to the length of radicles if the length of acrospire and condition of endosperm are favourable. The odour should be agreeable, and entirely free from mustiness or other evil smell. When very sweet and perfect, it strongly resembles freshly-cut cucumber.

If on rubbing or pressing a kernel it is not white and mealy, but hard, soapy, clung, or glutinous, it indicates an excess of protein-substances; and requires careful manipulation in kiln at low temperatures.

The reasons why drying malt is necessary and beneficial, are numerous.

Germination is completely and finally arrested.

The moisture is reduced to a limit that renders it incapable of injuring the other constituents of the malt.

The constituents are themselves modified and finally fixed, so that rightly-dried malt remains comparatively stable for lengthened periods. The influences of drying upon the resulting wort, or product of the malt, are very distinct and powerful.

The distinct influence of drying is commonly an increase of dextrine, modifications of the carbohydrates, &c., and acquisition by the grain of the all-important empyreumatic influences.

The malt becomes capable of lengthened storage, and best fitted for use in the mash-tun. It is also best adapted for transport and grinding when well dried.

Almost all mould and other fungoid growths are completely arrested, and their vitality is suspended. It is, however, a mistake to think they are effectually killed.

Professor Graham* says, "A slight error in the previous "malting or even mashing may not be serious, but a slight "error in the fermentation process is attended with very serious "results."

I, however, invariably assert that malting equals in vital influences the mashing, and is of much greater importance than fermenting.

This is essentially a brewer's question, but it is of importance to maltsters.

As a matter of simple fact, easily understood, by the quality of the barley, liquor and yeast used, or by the mode of steeping, growing, drying, and grinding of malt, and by the processes of mashing, stewing, and boiling, we can absolutely control our fermentation, but I never yet met a brewer in any part of the world who laid claim to the capacity of being able to alter a bad fermentation into a thoroughly sound and healthful one by watching or any amount of care and doctoring. When malt of inferior quality, or which has not been properly grown and carefully kiln-dried in the first instance, has been improperly mashed and boiled, the fermentation can in very few instances be described as a sound or good one.

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* Cantor Lectures, *Journ. Soc. Arts*, 1874.

The processes of malting and fermenting, bear, in many senses, the relation of cause and effect, and it is idle to attempt properly to influence effects, and continue to ignore causes. The objects of malting and fermenting are unlike and distinct in almost every detail, but they have this in common, that their main end is to produce a sound, pleasing, and profitable beer. Malting to a very great extent determines the character of the wort to be fermented, and the fermentation acts upon that wort badly or well, not only in direct relation to the quality and nature of the yeast added, and the conditions of temperature and other surrounding influences of the wort, but in a greater and more important manner according to the nature of that wort itself. The wort is not only the element surrounding the yeast-plant, but it is the food-supply also, and upon the character and quality of the food supplied, the development and well-being of the yeast-crop mainly depend. My own experience has taught me that kiln-drying and mashing exercise almost equally great influences upon the character of the wort, and as the one stage necessarily precedes the other, it must take the first place, especially as the influences of the kiln are more permanent than those of the mash-tun.

Much good beer has doubtless been made from very inferior malt, also vast quantities of so-called good beer are made by men who never even saw a proper mash ; but neither of these facts can upset or affect the assertion that it is necessary to pay strict and careful attention to the drying of malt to produce a wort of uniform quality and absolute soundness. By careful working, inferior barley can be made into fairly sound and useful malt. By the employment of considerable skill and having good plant, a brewer can make very good beer from indifferent malt, but his efforts, if carried back to the malt-house, are much more certain and reliable in their effects.

No brewer needs to be told how much easier is his work, and more certain in its results, if he has malt well-made and soundly dried.

To dry pale malt well three things are necessary.

1. It should be loaded in the condition just described as sound green-malt upon a floor at a thickness rarely, if ever, exceeding seven to eight inches.

2. It must remain *unturned* at a low temperature until nearly all moisture is removed.
3. Heat must then be applied steadily and freely, and be maintained for a considerable time at a nearly uniform height, ranging from 160° to as high as 230° in some cases.

With these three rules duly carried out, simple as they seem, vast quantities of malt now daily spoiled in the making, could be manufactured into a thoroughly sound and useful article.

Kilns work fairly which allow these conditions to be fully kept.

By far the greater proportion of the kilns now working in Britain can be easily and inexpensively arranged or altered, to enable these necessary conditions to be always attained with certainty in practice.

A really well-designed and good kiln can always ensure the following conditions.

Malt completely dried (*i.e.*, deprived of 97 per cent. of the total moisture present in green malt).
Uniformity of dryness, colour, flavour, and aroma.
Economy of working in cost of fuel consumed and labour employed.

One hundred and twenty years ago* maltsters deemed it necessary to dry off only three or four inches deep, some going so far as to allow ninety square feet to the quarter upon the kiln, but they almost invariably had kilns very imperfectly constructed, with a space of a few feet only from bars to floor, but little head-room, and the floors of horsehair, tiles, or plates, all badly made, and incapable of allowing free ventilation or passage of air. In many cases, also, *wooden* plates were used.

The best kiln, according to Champion†, is one "which dries "a given quantity of malt with the least quantity of fuel with "no injury to colour and quality."

The same practical maltster advises "an open room, 13 feet "high, not closed in with arched sides," and strongly recommends openings for air at each side of the fire. He prefers loading a whole wetting at once, and keeping it upon the kiln at a temperature of 90° for 18 hours, turning twice during the time. By gradually raising the heat, and frequently turning, the malt gets dried, and is finished at 120° for pale malt.

Some of the kilns constructed in the early part of this century had pipes variously placed to convey the heat directly from the fire to above the drying-floor, in order to dissipate the steam.

Over fifty years ago the importance of drying was recognised and

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* The London and Country Brewer. By a Person formerly concerned in a Public Brewhouse. London, 1759.

† The Maltster's Guide, p. 94.

written about,[*] and some curious facts are mentioned in a huge volume published in the early part of this century.[†] I deem it advisable to quote somewhat fully, but more modern experience teaches that nearly every deduction in these abstracts is erroneous. Increased temperature and lengthened cooking add to the stability of the wort and beer produced. This is now fortunately very generally believed, although still far too much malt and beer is spoiled for want of more perfect drying.
Shannon says :—" The further we pursue the deeper tints of
" colour by an increase of heat beyond that which simple pre-
" servation requires, the more we injure the valuable qualities
" of the malt. It is well-known that scorched oils turn black,
" and that calcined sugar assumes the same complexion.
" Similar effects are producible in malts in proportion to the
" increase of heat, or the time of their continuing exposed
" to it. The parts of the whole being so mutually united
" by nature an injury cannot be done to the one without
" affecting the other; accordingly we find that such parts
" of the subject as might have been severally extracted
" for the purposes of a more intimate union by fermentation,
" are, by great heat in curing, burnt and blended so effec-
" tually together that all discrimination is lost, the unfer-
" mentable are extracted with the fermentable, the integrant
" with the constituent, to the very great loss both of spiri-
" tuosity and transparency. In paler malts the extracting
" liquor produces a separation which cannot be effected in
" brown, where the parts are so incorporated that, unless the
" brewer is very well acquainted with their several qualities
" and attachments, he will bring over with the burnt mixture
" of saccharine and mucillaginous principles such an abund-
" ance of the scorched oils as no fermentation can attenuate,
" no precipitants remove; for, being in themselves impediments
" to the action of fermentation, they lessen its efficacy; and
" being of the same specific gravity with the beer, they remain
" suspended in, and incorporated with, the body of it, an
" offence to the eye and a nausea to the palate to the latest
" period."

" From this account it is evident that the drying of malt is an
" article of the utmost consequence. Concerning the proper
" degree of heat to be employed for this purpose, Mr. Combrune
" has related some experiments made in an earthen pan, of about
" two feet diameter and three inches deep, in which was put as
" much of the palest malts, very unequally grown, as filled it on
" a level to the brim. This being placed over a little charcoal in
" a small stove, and kept continually stirred from bottom to top,
" exhibited different changes according to the degree of heat
" employed. On the whole he concludes that true germinated
" malts are charred in heats between 175° and 180°; and that, as
" these correspond to the degrees in which pure alcohol, or the

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[*] Champion, The Maltsters' Guide [1832].

[†] R. Shannon, A Practical Treatise on Brewing. [1805] pp. 134—136. See also London Brewer, seventh edition, pp. 253 and 321.

" finest spirit of the grain itself, boils or disengages itself there- " from, they may point out to us the reason of barley being the " fittest grain for the purposes of brewing."

Probably, in the whole range of brewing, no experiments have been so delusive in themselves and productive of such serious and lasting mischief, as those of Combrune. I quote from his second edition (1804), in preference to the first edition (1762), because Mr. Combrune states in the preface of the later work that, " in many respects it differs considerably from the " first. I have endeavoured to convert to use every advice, " every opinion I received, and having put them to the test of " further practice, flatter myself it will be improved."

After forty years' practice, therefore, the grievous errors he perpetrated were apparently undiscovered—a very striking illustration of the advanced ideas of Mr. Combrune compared to the brewers generally of his day and generation.

From these experiments Mr. Combrune has constructed a table[*] of the different degrees of the dryness of malt, with the colour occasioned by differences of heat. Thus malt exposed to 119°, is white; to 124°, cream colour; to 129°, light yellow; to 134°, amber-colour; to 138°, high amber; to 143°, pale brown; to 148°, brown; to 152°, high brown; to 157°, brown inclining to black; to 162°, high brown, speckled with black; to 167°, blackish brown, with black specks; to 171°, the colour of burnt coffee; to 176°, black.

This account not only shows us how to judge of the dryness of malt from its colour, but also, when a grist is composed of several sorts of malt, what effect the whole will have when blended together by extraction. Experience proves that the less heat we employ in drying of malt, the shorter time will be required before the beer which is brewed from it is fit to drink; and this will be, according to the following table:—119°, 2 weeks; 124°, 1 month; 129°, 3 months; 134°, 4 months; 138°, 6 months; 143°, 7 months; 148°, 9 months; 152°, 10 months; 157°, 18 months; 162°, 24 months.

Ford[†] says that " the lower the temperature of the heated air " malt is dried with, the plumper and more productive is the " malt; but for fulness of flavour a higher temperature is " required." He recommends the following heats:—

Required Colour.	First Heat in Pit.	Gradually increasing to.	On Kiln.
White	90°	100° to 120°	95° to 105°
Pale	90°	100° ,, 135°	100° ,, 130°
Do. for Stock	90°	120° ,, 145°	100° ,, 135°
Pale Amber	96°	140° ,, 180°	120° ,, 170°
Dark	96°	170° ,, 190°	140° ,, 180°

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[*] COMBRUNE, Theory and Practice of Brewing, ed. i. pp. 103—105 [1762]; and ed. ii. 115—119 [1804].

[†] W. FORD, Malting and Brewing, 1862, pp. 121, 122.

These heats are for well-constructed kilns. High colour is given by sudden changes. The heat in pit, till steam is well off, should not exceed 100°, and then be gradually increased with as great a volume of air as can be obtained for pale malt. All air admitted to pit should be rarefied by fire in its passage. Malt should be turned. Never discharge from kiln until fire has burnt low and clear, and the malt been rounded up in centre of kiln for two hours at least.

If the draught is good, dry 10 in. to 12 in. deep; if bad, only 5 in. to 7 in.

" *It is therefore obvious that the skilful preparation of malt " on the kiln must have the greatest influence on the quality of " the worts made from it.

" As far as the malting process is concerned, I believe we are " perfect, but in the drying we have much to learn; our pre- " sent plan, although greatly improved of late years, is still " defective."

As time went on, kilns were gradually increased in height and effective power, but, strangely enough, this additional power was used to add to the quantities produced rather than to the quality of the malt made. The restrictive character of the many laws passed year by year made improvement difficult, but maltsters had themselves more to blame than the Excise, for, had they really wished to alter the system of drying, the authorities would inevitably have given consent.

Still, the more enlightened and skilful maltsters came to the knowledge of the greater value malt had in brewers' esteem when it was kiln-dried—*i.e.*, kept at high temperatures for a few hours before being thrown off; and the duration and intensity of this process were steadily increased, until, at this moment, very many maltsters keep their floors from eight to twenty-four hours at heats exceeding 180°, thereby adding greatly to the satisfaction and credit of the brewers using the malt so dried. By somewhat indifferently attending to the rules of cause and effect, and justly, though perhaps roughly, attributing some satisfactory and desirable results to easily-managed modes of procedure, they arrived at a conclusion from merely practical rule-of-thumb working. This conclusion the more skilful brewers of our own time have been enabled to put into scientific and technical language, which at once enables laws to be framed, so far as existing knowledge will permit, that can absolutely point to those practices which must be avoided, and clearly indicate some others which are desirable.

Careful workers know that a wort produced from thoroughly-dried malt is pure and sound, more pleasant to the palate, and better able to produce a stable, fine-flavoured ale of attractive appearance than any malt which is in any form unsound. Hence it follows that, as clearly-defined effects are known to proceed from easily-regulated and controllable causes of simple and practical nature, these effects and causes are worthy the careful consideration of all interested; and the laws ruling them, if viewed from the point of perfect malt-drying only, are reducible to the three rules already indicated (pp. 361, 362).

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* W. Ford, Malting and Brewing, 1862, p. 123.

For these rules to be properly carried out, it follows also, as a matter of course, that the construction of the kiln should freely admit of it; if not, then it should be altered or rearranged. Let the full force and meaning of these rules be but understood and acted upon, and many maltsters would be lifted from the sloughs of despond into which they now frequently fall, and would find a ready market for their malt.

Herr Carl Cermak, in Der Böhmische Bierbrauer, makes the following enthusiastic statement:—

" The kiln-drying of malt is conceded to be so important a " process in the brewing industry that a dogmatical determina- " tion of its object, and of the laws to be observed during the " manipulation, appears very desirable.

" Taken as a whole, kiln-drying is undoubtedly the most " important factor of the labours devolving upon the brewer, " for it regulates the principles of, and the conditions essential " to, brewing, and removes impediments that would render the " growth and prosperity of the brewing industry impossible. " Taking into consideration the development of the brewing " industry, we find that the results attained within the last " few decades are principally due to kiln-drying, and that only " since a thorough and correct system of kiln-drying was " adopted has a proper impulse and wholesome stimulus been " imparted to the industry. The requisite keeping ability of " the malt could not be attained without kiln-drying, and con- " sequently the industry would have to contend with almost " insurmountable obstacles. Without kiln-drying, there would, " furthermore, be no field for engaging in barley-speculations, " and producing more malt than actually required for con- " sumption. Kiln-drying imparts to the beer those charac- " teristic qualities which have made it so universally popular " a beverage; kiln-drying it is that enables us to keep our " breweries constantly in operation; it is kiln-drying that " renders beer durable for an extended period, and makes it " capable of being transported.

" Summing up all the results attained in the modern brew- " ing industry, we shall arrive at the irrefutable conclusion, " that it is principally the rational kiln-drying of malt that has " made beer a fashionable beverage, and that without the system " adopted the rational production of beer would be entirely " out of question. A long time elapsed before correct opinions " in regard to kiln-drying gained ground; at the present time " its task and object differs widely from that of former days, " and it is impossible that, in consequence of the constant " progress, new laws should be determined, upon which kiln- " drying of the future will be based."

No hard and fast rule can be made in drying, as to the actual temperatures to be employed, the duration of particular temperatures, or the length of time necessary to complete the process of drying.

Apart from the variations in kilns, and the difference in working of kilns seemingly alike; apart also from the differences naturally found in the varied fuels employed, one great factor has hitherto been too little considered in the operation of drying. Air has all the work to do in a kiln, and the state of the atmosphere must naturally exert great influence upon the quality of the malt produced, the duration of the process of drying, and the consumption of fuel. If the air supplied to a kiln-floor has already reached the limit of saturation, as during a heavy fog or protracted rain, then it follows that the power of the air to dissipate the moisture from a floor of green-malt is ruled by the difference in temperature of the air when heated and when cold, and its consequent capacity of absorption of further moisture. (See pp. 36—39.)

In Great Britain it very often occurs that the air has nearly reached its saturation-limit at normal temperatures. Such air, necessarily, cannot properly dry malt. To this fact must be attributed the otherwise inexplicable and curious phenomenon of malt after having been maintained for many hours at a temperature over 220°, yet retaining 2 to 4 per cent. of moisture. It is fair to assume that much malt dried upon kilns of most erroneous construction has nevertheless never attained a higher temperature than 150°, and some not so much.

When so low a temperature as 145° in kiln is never exceeded, malt may be very pale, and appear sound, but it is impossible for it to keep properly itself or make satisfactorily-keeping beer.

The following are the temperatures adopted by Herr Chodounsky, a well-known Bohemian maltster. At the time of charging the kiln, a temperature of 108° Fahr. should be indicated by the thermometer hung underneath the upper floor of the kiln; two hours afterwards the temperature should be 111°; at the expiration of three hours, 113°; and at four hours, 117°; after five hours, 122°; after six hours, 133°; after seven hours, 144°; and at the expiration of eight hours from 156° to 160°. The maltster ought not to allow a variation of more than 4° from the above temperatures. The temperature of the malt on the upper floor is thus under control, and ought to acquire the following temperatures at each successive hour—80°, 84°, 86°, 99°, 102°, 111°, 117°, and 131°. The malt should reach the lower floor of the kiln at 129°, and pass from hour to hour to the following temperatures: 117°, 116°, 130°, 133°, 147°, 171°, 178°. The malt is charged so that the thickness of the layer of grain (24 square feet per quarter) is a little over 3 in. at first; after four hours, about 2¾ in.; and after eight hours rather less than 2½ in. On descending to the lower floor of the kiln, it should not exceed the last-named thickness, and towards the middle of this stage the thickness should be reduced to 2 in., and at the end of the kiln-drying be a trifle less.

These temperatures and thicknesses of grain are to a certain extent correlated, but both are undesirable for malt used by the infusion-method of mashing.

Dr. Graham* says of the German process of drying:—

"In the German process, the malt, which has been pre-
"viously withered and air-dried on the withering-floor, is
"placed on the upper kiln-floor, the temperature of which is
"about 100° Fahr.; here it remains for some hours, until the
"moisture is reduced to about 5 per cent., when it is let down
"to the lower floor, which is heated to 170° Fahr., and in some
"cases to a higher temperature, towards the end especially,
"when a greater yield of dextrine is desired."

There is a strong opinion that malts finished off at very high kiln-temperatures produce the soundest and best-flavoured beer, and there is much truth in this; at the same time it must not be overlooked that excessive temperatures applied during the final drying stage render the reproduction of yeast during fermentation somewhat sluggish, through the tendency of high temperatures to render the albuminoids less capable of acting as yeast-food. There are thus two extremes: slack malts give in many instances fiery fermentations, and certain unsoundness of resulting beer; while overdried malts produce sound, well-flavoured beer, with comparative shortness of yeast-crop. Now as it is necessary to have sufficient yeast reproduced for use, to avoid constant changes, it is quite as well not to overstep the limit of heat during kiln-drying which is consistent with this normal reproduction. This is of course influenced by the method of mashing and fermenting adopted, and the nature of the water employed, and the right consideration of these points at once draws attention to the desirability of the brewer having the control of the making of the malt he uses.

Thus, in some positions, it is at present unsafe to use malt dried at temperatures nominally about 190° (probably 230°), and I know many cases where the malt is dried at temperatures exceeding 220°.

The character of the yeast-plant may itself produce very marked influences also upon the flavour and appearances of beer as well as upon the vigour of its own reproduction. I venture to think that when the wide field of research, which this subject opens up, is more fully investigated, it will be found that the counter and prior influences of the constituents of the wort, especially so far as they are influenced upon kilns, will be decided to be the greater, and ultimately will be regarded in the light of cause, yeast taking the secondary place of effect.

My first rule is—malt should be loaded at a proper stage upon a floor at a thickness not exceeding seven to eight inches. By a proper stage I mean solely well-grown and properly-nourished green-malt fit for the kiln (see p. 356). My reasons why it should not exceed eight inches in thickness are:—

I. With any less depth, the moisture can be removed freely and rapidly, with no injury in any form to the drying malt.

II. The labour of turning is largely saved.

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* Dr. Graham, *Journ. Soc. Chem. Ind.* 1881.

III. The heat of the whole of the malt can be maintained with much greater regularity than is possible with a greater depth.

IV. With moisture present in green-malt, the starchy, saccharine, and albuminous bodies are much more easily broken up than when dry; hence, more decomposition is produced with a low moist temperature, and the conditions are very favourable for the production of acid.

The varieties of acid produced in malt are very numerous. Naturally, they vary considerably in amount, many of them being present only in minute quantities. Still, the subtle influence upon flavour of minute quantities of ill-defined and strangely-named compounds is truly marvellous.

Doubtless, as our knowledge becomes more exact, and our scientific training more thorough, permitting more accurate estimation of the deeply-hidden (so-called) secrets of nature, many of the things that now puzzle and perplex or baffle us, will be found really very simple, and cause and effect will be as easily traced as in the myriad other dealings of man with nature where our predecessors have been harassed.

A large number of German chemists, and some in our own country, have given the subject of organic acids in malt and worts considerable attention.

Lermer* mentions the existence in malt-combes (rootlets) of the following acids: acetic, asparagic, citric, formic, lactic, malic, oxalic, propionic, succinic, tannic, and a fatty acid.

In addition to the acids, he also determined the presence of asparagin, cholesterin, gum, resin, sugar, and wax. (See pp. 175, 176.)

Dr. Graham† states "that in the presence of moisture,
" starchy bodies and saccharine bodies, and also the albumin-
" ous, are much more easily broken up than when moisture
" is not present. In other words, if they be dry, a higher
" temperature is required to produce as much decomposition as
" is produced by a low temperature when moisture is present.

" Now, too sudden heat produces what is called a hardening
" or vitrefaction of the starchy or dextrine matter; on the
" other hand, a too low heat does not give some of the advan-
" tages of the kiln-drying process, because it leaves the kiln
" with moisture, and still very liable to absorb more, and con-
" taining a larger quantity of the destructive albuminous con-
" stituents, and less of the empyreumatic bodies. So that this
" question of kiln-drying is excessively important.

" This, of course, is a matter of great importance, because it
" not only fulfils the conditions which the consumer requires,
" but by the advantages which the high colour presents, it,
" like charity, covers a multitude of sins. It is much more
" easy to work with a high-dried malt than with a very low-

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* LERMER, *Polyt. Journ.* bd. clxxix. pp. 71—80 [1866].

† GRAHAM, Cantor Lectures, *Journ. Soc. Arts*, 1874.

" dried malt. As regards the thickness of the floor, it seems to " me, from what I have seen, that the usual thickness in Eng- " land is far too great. I have seen it twelve and eighteen " inches thick, and sometimes even thicker still—thick and wet.

" Now so long as you keep barley in a very moist condition " at a high temperature (and 80°, 90°, and 100° Fahr. are high " temperatures) so long do you keep up the conditions neces- " sary for the production of acid; and I never yet examined a " sample of malt dried in that way that did not contain much " acid."

Further patient and careful investigation of this subject is greatly needed. These facts may, however, be accepted as certain, viz., that some of these acids are present in malt, and are carried through into the wort produced. When found in wort, even if only in most minute quantities, they can exert influences over flavour, condition, etc., of the finished product, apparently out of all proportion to the amount present.

That these acids can be largely influenced by each of the processes of malting may be taken for granted, but few conditions can be more easily conceived to produce or stimulate them than loading a kiln with from twelve to eighteen or more inches of green corn and applying gentle heat. Ordinarily such a depth of corn has to be turned somewhat frequently.

In this one place alone we may confidently look for a large factor in the want of uniformity in malt wort. Irregularities in fermentation and beer cannot by any possibility be avoided when made from such malt.

Reverting to the subject of the old fallacy of the paramount importance of fermentation in brewing, the presence of lactic acid is unfortunately not inimical to healthful appearances of yeast and fermenting wort. Some authorities hold that lactic acid is beneficial in malt. Dr. Bersch says that a difference of ·001 per cent. in the amount of propionic acid in a wort would occasion a slower rate of attenuation, and diminish the crop of yeast.

If an appreciable percentage more or less of lactic acid made as marked a difference, we should not find many kilns loaded so deeply as the majority now are.

It is obvious that the thinner the layer of drying malt is in a kiln, the greater must be the rapidity of its drying (other conditions being equal).

Were drying anything other than a cooking process, the more rapidly it could be accomplished the better its effect. This I know from practice to be distinctly wrong. The application of certain temperatures for given periods of time, with and without certain percentages of moisture present in the grain, exert distinct and easily recognisable influences. It is also equally certain that the assumption is just, that the other influences exerted, of which I have at present too little knowledge to be able accurately to estimate, or even to identify or recognise them, are nevertheless important factors in the production of a malt that is the best possible to be obtained from the barley used.

Green-malt, containing too much moisture when loaded upon kiln, must necessarily become vitreous and steely, unless exceedingly great care is taken to regulate temperatures and air-supply for the first two days' drying.

Secondly, malt should remain *unturned* at a low temperature until nearly all moisture be removed.

The reasons already given, attempting to show the evils of moisture with improper heats and acid reactions, are all intensified when the question of turning is considered. No maltster of average intelligence should require to have pointed out to him the numerous evils resulting from turning hot dry malt from the kiln-wire or tiles and placing it upon a layer of reeking, sodden grain, freely giving out its moisture. This, of course, is absorbed with avidity by the dried malt until in turn it also becomes wet. Few things absorb moisture more freely than warm, dry malt, and accordingly when placed in a heavy, vapourous atmosphere, it speedily gets wet. In many places this turning is effected as many as twelve or fifteen times, and the result is a malt of bad flavour, and high percentage of acid, for it has been dried and wetted an equal number of times. It is, in addition, hard and steely, so that if broken it presents a vitrefied appearance, and must be of a generally unsatisfactory character.

If, on the other hand, drying malt remains unturned, until 90 to 95 per cent. of its moisture is driven off, then the malt is of superior flavour and very tender, with little trace of acid, and the wort produced by it is regular and more easily fermented, presenting little or no different result if tested for acidity by the cold- or warm-infusion-test. (See p. 157.)

This has now been conclusively proved in many malt-houses where my system has been adopted, for the majority of the maltsters so working find it entirely unnecessary (as well as undesirable) to turn on the upper floor.

All that is needed is an occasional loosening of the top crust with a fork or plough.

Professor Graham, in his very able Cantor Lectures, delivered before the Society of Arts, 1874, pointed out the German arrangement of double floors in kilns, and the great advantages to be derived from their adoption, if only the empyreumatic properties of the malt could be retained, in the following remarkable words:—" Not only do I consider the thickness of 12 to 18 " inches too great, but I even consider (and there I am not so " confident, because it is an engineering question) one kiln-" floor to be bad. In the first place, I consider it to be bad, " because your malt must be thicker, and because it is more " difficult to regulate the heat than when you have two, and " also because it is more difficult to get rid of the moisture; " then, lastly, because more time is required, and instead of " the process being finished in a few hours, it takes some three " or four days, sometimes even more.

" The advantages which two floors present are evident. In " the first place, it enables you to have your malt thinner, it

" enables you to regulate your temperature better, and to " regulate it in two distinct stages by having a lower tempera- " ture in the higher floor and a higher temperature in the " lower one. You may say, Oh, we get rid of this difficulty " with reference to the thickness and the moisture by repeated " turning. I say, you do *not*. The more you turn the malt, " the more you shut in the moisture, because it is the upper " layers that get wet, and after the lower ones get a little dry " you turn up the layer which is dry, and so the dry malt gets " wet again, and this has to go on for several days.

" All the time the wet malt is on the kiln at a low tempera- " ture putrefactive action is going on, due to the solution and " the oxidation of the albuminous matter.

" If you have wet malt and very thick (12 to 18 inches), you " must have a long time, and hence there must be a greater " amount and continuance of this putrefactive action set up."

The sagacity of the learned Professor's reasoning has been proved now in many scores of malt-houses built or altered by me to what some gentlemen have the courtesy to call the Stopes' system. This has also been largely imitated by others, much to my satisfaction.

So far as I can yet learn, I was the first practically to adapt this system to the requirements of English maltsters, and with perfect success, as the malt made in kilns of my construction with two floors is superior in many ways to that previously made in the same houses.

It is singular that this suggestion was made so long ago, and although kilns with two floors were erected in Great Britain long prior, for drying peas and ungerminated grain, yet the use of such kilns for malt was never practically effected, notwithstanding the suggestive patent of Stead in 1842.

The kiln in which malt was first succesfully dried upon a double floor in Great Britain belongs to Colonel Tamplin, Brighton, and the untiring courtesy with which both he and Mr. Tasker have shown it to hundreds of maltsters is gratefully acknowledged by me.

The plan of two or more drying-floors has long been known on the Continent; and I have been in large numbers of the kilns while at work in many countries.

None of these, however, prior to 1882, worked properly, so as to enable the products of combustion to come into direct contact with the still sodden but drying malt. Since 1882, I have constructed several kilns abroad.

The mode of working I adopt is a combination of the best features of the very many I have seen in the majority of the countries in Europe. It enables a greater quantity of malt to be made than formerly, and at less cost, the only restriction to the quantity made being the capacity of the growing-floors, and not of the kilns, as is now too frequently the case. The best plan when adopting this system to an existing malt-house, is at once to diminish the quantity of the barley steeped by from 30 to 50 per cent., and to wet with double the frequency, *i.e.*, instead of wetting, say, eighty quarters every four days, or three times a fortnight, to steep fifty quarters every two or two and a-half days, if the growing-floors will fairly carry it. (See p. 186.)

Although wetting with such frequency, it is nevertheless easily possible to retain the corn on the kiln the full time of four or even five days, if desired. The whole piece, when ready, is raised at once to the upper floor of the kiln. There it forms a layer of four to six inches in depth, and, *without turning*, lies until nearly all the moisture has passed off. Commonly it is desirable to plough, or fork-over two or three times. Then it can easily drop through doors or holes to the lower floor, which of course is a very effectual turn, but as it is by that time hand-dried, little or no harm is done to the malt. The space then becomes available for another piece, or it can sweat a load of barley, if the following floor of green-malt is not fit. When practicable, it is preferable to keep on the top load of malt, and sweat on bottom floor. The partly-dried corn is then kiln-dried at a temperature of from 180° to 190°, *or more*, and the same heat and air that effect this are the very best possible to dissipate the moisture from the upper floor. Hence, the corn may remain two days on upper floor, and two on bottom if desired, and it can be dried with no turning in any form during such time, with the exception of the ploughing or forking already mentioned.

Some other writers have hinted at the impropriety of turning malt when still moist. Thus Black* says "There is a prevailing error that malt should be frequently turned on the kiln during the process of drying. A little consideration, however, will show the inaccuracy of this opinion. It has already been stated when the proper currents of heated air are introduced in drying, no colouring of the malt need be apprehended. If the kilns be properly constructed, turning is not only unnecessary, but injurious, until the malt be nearly ready for removal from the kiln, when several turns, with a brisk fire, may be necessary to render the dryness of the malt uniform; by which also the malt will be rendered uniformly mellow."

Ford says†, "In drying *pale* malt the less it is turned the better. If the kiln be well constructed, with a good draught, it should not require turning more than twice."

Steiner says‡ "Malt while yet damp should merely be loosened, and not turned, to prevent gelatinization and steeliness."

There can be but little objection to turning, if it is almost continuously done, say by running at very frequent intervals a Perry's or Schlemmer's turner. This always adds to the cost of making, and very considerably so, in places where power is obtained from steam or gas. It also allows the continuance of the existing waste of fuel, for in every case where a double floor is used, it is obvious that the saving of fuel is necessarily considerable.

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* W. Black, a Practical Treatise on Brewing, pp. 21, 22.

† Malting and Brewing (1862), p. 122.

‡ I. Steiner, The Principles of Malting, *Brewers' Journal*, 1883, pp. 86—91.

A second floor, properly working in a kiln, entirely obviates the necessity for turning the malt drying or finishing upon the bottom floor. The only benefit to be derived from turning at this stage, so far as I can learn, is to regulate temperatures, and ensure as much uniformity as possible for the malt. In an ordinary single-floor kiln this is doubtless a very necessary process, as it is obvious that the top surface of a layer of malt, radiating its heat freely into the comparatively cool space of the top of the kiln, and assisted by the ascending column of air, must necessarily be colder than the bottom surface of the same layer which is resting on the hot wire or tiles, and is in immediate contact with the whole of the heat given off by the fire below.

That this point has failed to attract serious and earnest attention, puzzles me greatly. So far as I can learn, however, no one has paid any regard to it but Mr. Abbot, of Burton, and I have not yet encountered any publication whatever upon the point, excepting those for which I am responsible.

This, perhaps, is not to be much wondered at, as only ten years ago a man of such experience as Dr. Graham publicly stated,[*] "I do not remember ever having seen a thermometer " in a malt-kiln," and I can confirm this even now, notwithstanding all the controversy I stirred up upon the subject, for I find large numbers of maltsters who never use a thermometer in the kiln, and I can still say I have never seen a thermometer in a steeping-cistern, or encountered a maltster who systematically uses one to record the heat of steeping-liquor, excepting a few whom I have induced to adopt the plan.

If less time be taken upon the lower floor—and thirty to thirty-six hours are usually enough for much malt—a further advantage is to be derived in having a kiln at liberty quite long enough to dry or sweat any barley which may be improved by it. Maltsters would often do this, if they had kiln-room, but not having it, they steep the barley just as it is received, often against their judgment, and at great loss. With the double floor abundance of drying-room is provided, and the heat is supplied at no cost whatever, as it is drying the upper or lower floor, and, if not utilized in this manner, would simply pass away into the air in the wasteful manner now so customary.[†]

Thirdly. "Heat must then be applied freely, and maintained " for a considerable time at a nearly uniform height, ranging " from 160° to 230°."

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[*] Cantor Lectures, *Journ. Soc. Arts*, 1874.

[†] Mr. Southby, writing to the *Country Brewers' Gazette*, 1884, says:—"There is " no doubt great room for improvement in the old-fashioned kilns found at many " maltings in this country, and it is certainly the height of folly to continue to " spoil malt on these badly-constructed kilns. But the remedy lies in making a " simple kiln with a single floor, giving ample kiln-space, so that the malt need not " be laid on too thick, and increasing the draught by raising the height between " the fire and the kiln-plate, enclosing the fire, and conducting the air upwards in " such a manner that the hot air may be mixed with external cold air to any " extent that may be required, without damping the fires."

This, I am glad to know, is becoming a generally recognised necessity in making good malt. I have already taken the subject up at some length, but the confusion of ideas and positive ignorance upon the point is well exemplified in the table of malting temperatures, p. 389.

When malt contains any considerable proportion of moisture, exceeding, say, 12-15 per cent., it should on no account exceed a heat of 120°. When, however, it is dropped from the upper to the lower floor, it is so nearly dry that a greater heat can be imparted with benefit. This is best done gradually. No definite rule can be given as to the final limit, as that is ruled by a variety of circumstances. Some malts intended for particular purposes, drying upon certain (usually old) kilns, cannot, without damage, stand a heat of 170°, or even less.

Other kilns, drying malt for other purposes, or for use in particular breweries, are capable of maintaining a finishing heat of 230° with immense advantage.

A safe general rule is to be found in the medium of 180° to 185°, provided the whole of the malt be really at this temperature.

The great point is the maintenance of a perfectly uniform temperature, *i.e.*, the whole of the malt drying must be of the same degree of heat.

Single-floor kilns of the ordinary type, especially when thickly laden, must necessarily vary considerably in temperature. Take a floor with, say, nine inches of hot, dry malt upon it. The lower two inches, next the wire or tiles, are too hot; the central six inches are of about the right temperature; the top layer permits the heat to radiate freely, and is as a consequence too cool, frequently to the extent of 70—80°.

Frequent turning of a floor of this character is a necessity. At best it is a bad process, and is a great loss of energy and time.

Few maltsters know the actual temperatures of malt when drying. It is true that recently some use thermometers for the purpose of ascertaining, but the heat is rarely taken accurately.

As a consequence, few are aware of the wide differences to be found in a succession of dryings, or even in a single floor.

I have experimented upon this subject, and have found the result of such tests as I have made sufficiently astonishing.

As illustrations, I will give the records in the dual form that I adopt for registry, of one particular kiln and other kilns in Norfolk and Burton.

The first kiln has the reputation of being a very good one. It is constructed on "Free's" principle (Mr. Free having been paid his royalty upon its construction), and when tested was nearly new. It would be difficult to find any single-floor kiln giving better results, or so good. The proportions and areas of this kiln are not such as I can fully recommend, and I rejoice to see that Mr. Free advocates the use of a second floor, for the benefit to all users of his kilns must necessarily be very considerable.

TABLE A.

Time when loaded, 1882.	Heats—Centre of Kiln.				Heats—South Corner.				Heats—North Corner.				Heats—Hottest Place.					Remarks.
	Surface.	One inch from surface.	Centre of malt.	Close to tiles.	Surface.	One inch from surface.	Centre of malt.	Close to tiles.	Surface.	One inch from surface.	Centre of malt.	Close to tiles.	Surface.	One inch from surface.	Centre of malt.	Close to tiles.	Heat in chamber 12 inches below tiles.	
Mar. 27, noon „ 29, „	108°	116°	112°	148°	112°	126°	128°	161°	114°	126°	132°	159°	116°	121°	140°	165°	148°	Air clear. Strong gale and sunshine. Malt almost dry.

TABLE B.

Date when loaded, February 20, 1882.	First Day.				Second Day.				Third Day.				Fourth Day.			
	Near surface.	Centre.	Near tiles.	Twelve inches below tiles.	Near surface.	Centre.	Near tiles.	Twelve inches below tiles.	Near surface.	Centre.	Near tiles.	Twelve inches below tiles.	Near surface.	Centre.	Near tiles.	Twelve inches below tiles.
1st hour ..	98°	101°	110°	150°	105°	118°	128°	110°	160°	158°	178°	162°	180°	180°	182°	178°
4th „ ..	105°	100°	115°	109°	128°	130°	148°	135°	163°	161°	182°	171°	178°	178°	180°	170°
13th „ ..	125°	150°	156°	138°	134°	138°	146°	138°	180°	180°	181°	186°				
19th „ ..	131°	146°	148°	142°	134°	140°	144°	142°	188°	188°	193°	183°				

My second illustration is from a malting situated at Wells, Norfolk. This was publicly put forth as a perfect kiln, giving good results—better, indeed, than any kiln of my construction—but it was tested by me December 14th, 1883, and gave the succeeding interesting results.

Scant examination of the following facts and diagram show incontestably that, with the most careful management, properly-dried malt is in this or any similar kiln an impossibility. Such results as I found in it could under no circumstances be attained at any kiln over which I have control.

This is a malting steeping 105 qrs. every four days, and has a kiln 75′ × 36′; an average drying-area of under 26 ft. per qr. The consequent depth of green malt when loaded is over 10 ins. The total area of air-inlets is less than 27 ft. super. The air-outlet exceeds 117 ft., a ratio of 13 to 3[*]. The capacity of head room equals 44,550 cubic feet. The area of each tile is 114 in. with 546 holes, giving an effective area for air of some 32 in. The ratio of non-effective metallic surface to air-space is thus 9 to 2. The most palpable defect of the malt is probably attributable to these tiles.

A fine drizzling rain, accompanied by a very gusty wind from the N.E., made the hygroscopic condition of the air so bad that I did not waste any time testing it. Bearing in mind the conditions I have already indicated, I was not surprised to find the Casella anemometer give no indications at several points, and it indicated fluctuating up- and down-draughts at many others, especially at two corners and along the centre. The strongest upward draught pulsated with the gusts of wind, and ranged from 30 to 54 ft. per minute, a down-draught of equal intensity occurring at intervals at the same spot, notwithstanding the fact that the air was constantly rushing in at the restricted inlets below the floor, at the high velocity of 785 ft. per minute.

The temperatures of the drying malt and superimposed air consequent upon the conditions thus indicated, were naturally as follows (see Fig. 144):—

At A, the supposed coldest place.

Heat of malt next tiles	174°
,, ,, 2 inches above tiles	143°
,, ,, 4 ,, ,, ...	135°
,, ,, on surface	104°
The heat of the air 3 feet above tiles ...	84°
,, ,, 5 ,, ...	82°

At B, the supposed hottest place.

Heat of malt touching tiles...	216°
,, ,, 1 inch above tiles	167°
,, ,, 3 ,, ,, ...	154°
,, ,, 4 ,, ,, ...	152°
,, ,, 5 ,, ,, ...	142°
,, ,, on surface	112°

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[*] A comparatively new kiln at Luton, altered under my direction, had the ratio of outlet to inlet nine to one, and it did not work very nicely!!

The diagram, Fig. 144, shows the temperature at 24 points close to the tiles, taken with twelve registered and accurate thermometers in the space of fifteen minutes.

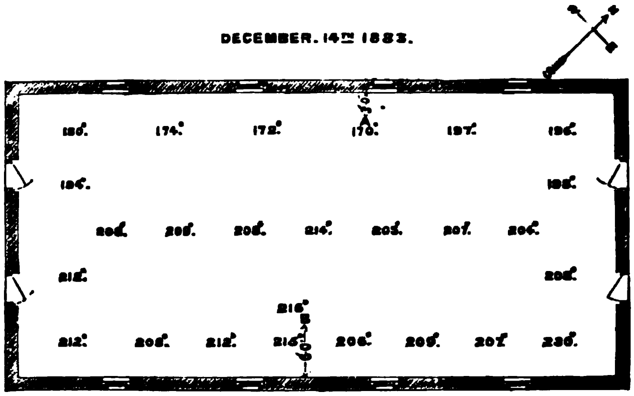

FIG. 144.—DIAGRAM SHOWING TEMPERATURES OF MALT UPON THE DRYING-FLOOR OF 105-QUARTERS KILN AT WELLS, NORFOLK.

A, supposed coldest point. B, supposed hottest point.

The significance of these facts is at sight apparent to those who understand the subject. They conclusively confirm the opinions I so frequently express, and which I have formed after careful examination of the structure and working of many similar kilns.

I can only repeat a phrase frequently used by me that I have yet to see *any single-floor* kiln drying malt properly. I know it to be *an impossibility*, and will prove it at any kiln whatever in Great Britain.

The third case I will mention is a nearly new malting at Burton. This is a splendid house, and is supposed to be an extremely good one. The proprietor laughed to scorn my statement that his heats varied greatly, but on testing a floor with a proper set of thermometers I found that when drying, as he imagined, at 190°, in one place next the tiles the heat was 237°, and at another, under the outlet on the surface, it was 162°. Thus a portion of this malt was 75° colder than another portion of the same floor.

These tables show that greater differences of temperature in the malt on drying-floors exist than are usually suspected. All are taken from ordinary workings, and equally astonishing results would be furnished by nearly every single-floor kiln now in use.

Fig. 145 shows the true heats at every part of a floor of malt drying at Poole, November 3rd, 1883. These are the actual heats of every part of the kiln at both bottom and top surfaces of the under-floor.

The second floor in a kiln affords another distinct advantage at this point. The upper floor, with its charge of corn, causes an almost perfectly uniform temperature to be maintained in the bottom floor when "kilning-off," so long as the fire is duly regulated. It causes the room between the two to be, in fact, a distributing-chamber, and the difference in temperature of any part of the upper or lower floors is hardly appreciable as a direct consequence. Turning is therefore almost needless. The average temperature may be greater, and yet the heat applied may be less; for we have the heat below the floor reduced in a direct ratio to its increase in the space between the two floors.

Numerous other advantages are evident. The most important are:—

The saving of fuel.

The quality of the malt made is considerably improved.

A greater percentage of the extractive matter of the barley is obtainable by the brewer or other user of the malt.

The percentage of acidity is much reduced.

The stability of the beer is increased.

The total labour is reduced.

The capacity of many existing houses is greatly increased.

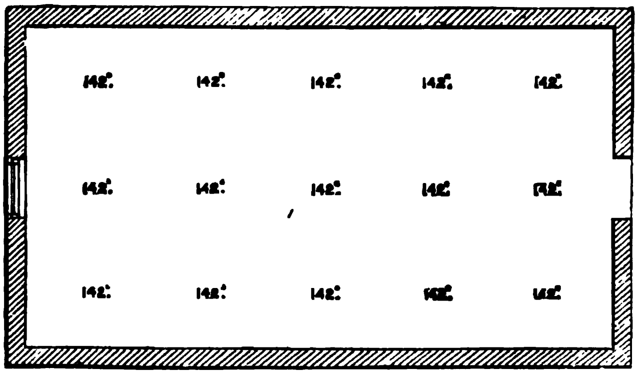

Fig. 145.—Diagram showing Temperatures of Malt upon the Drying-Floor of 35-quarters Kiln, Poole, Dorset, 3rd November, 1883. Stopes' System.

These, with numerous other advantages, must eventually be recognised, and cause my system to be largely adopted.

The uniformity of temperature and its control ought not to depend upon the care of the maltster or fire-man, no matter how attentive he may apparently be.

Surely mechanical contrivances are in this instance much to be preferred to the most skilful and reliable human (and therefore fallible) attendance.

Several arrangements intended to effect this are successfully working.

The electric thermometer, placed in the air-chamber of the kiln, is useful. A thermometer having a thin platinum wire inserted in the tube is fixed in any position below the floor. A battery of two cells is placed in any out-of-the-way corner, bells are fixed in the malting or office, or wherever the warning is desired to be given. A very slight amount of practice will speedily determine the temperature needed to give any required heat upon the floor. The wire is set at, say, 1° or 2° above this point. When the heat exceeds the required standard by 1° or 2°, the mercury touches the wire, and instantly the circle is complete. The electric current traverses it and sets all the bells ringing, until attention by the maltster to the fire lowers the mercury, and the bells cease. The same arrangement will also indicate any required minimum temperature and so prevent undue cooling down.

Another exceedingly good contrivance is King's automatic heat-regulator, as this practically attends to the fire itself during the night, and will regulate the heat with great accuracy, without attention in any form. It has the control of a damper working by the displacement of mercury by heat, in a wheel of large diameter. (See p. 291.)

Some maltsters still adhere to the practice of heaping the dried malt, when finished, on the kiln-floor for some seven or eight hours before the completion of drying, and letting the malt remain so heaped for twenty minutes or half an hour. On the completion of the drying process, provided the malt is not overheated or coloured too much, it is allowed to rest on the kiln, the fire being backed down, until the next floor is ready for loading. This plan is intended to equalise the heat, and it is said it improves the flavour of the malt. Where maltsters finish off from 170° to 180°, this is very probably the case.

It has long been recognised that the rapid increase of heat in a kiln is baneful. Thus Muspratt states[*]:—

" If the drying commences with too great a heat, the outer
" part of the grain hardens, and prevents the interior moisture
" from evaporating; should this be driven off by too high a
" temperature, the husk will in all probability split and the
" farina become horny and very refractory in the mash."

Dr. C. Michel[†] has pointed out that " the larger the pro-
" portion of proteid matter in the green-malt the more stub-
" bornly will the moisture be retained by the malt, and the
" more careful and prolonged must be the drying. Two
" different conditions prevail in malt-drying. We may dry
" with much air and little heat, or we may endeavour, in
" addition to the expulsion of the moisture, to effect certain
" chemical transformations in the grain. To this end we need
" much heat and little air. In drying malt by exposing it to
" profuse aeration, accompanied by comparatively little heat,
" we obtain a product suitable for producing a light-coloured
" vinous beer, without palate-fulness (Bohemian beer), subject
" to the proviso that the grain has germinated rapidly. Malt
" produced under the former of the above-mentioned conditions
" is unfavourable to yeast growth, and where such is in use,
" repeated changes of yeast are necessary, particularly when
" the germination has also been rapid. For higher degrees of
" palate-fulness the construction of the drying-floors must be
" taken into account as well. These may be classed under the
" heads of the so-called English system, and the hot-air system.

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[*] Chemistry Theoretical and Practical.

[†] *Zeitschr. gesammt. Brauw.*, 1880, No. 22.

" Floors on the English system have horizontal tubes, and " receive their supply of air through air-passages opening " directly beneath the grain. Those on the hot-air system " have vertical air-passages, and the heated air is supplied at " the lowest level by means of a hot-air chamber. Not unfrequently " the two systems are advantageously combined, so " as to admit of the utilization both of heated air and radiant " heat. Where the green-malt is to be so dried as to ensure " more or less perfect solubility with a greater or less percentage " of protein, it must be subjected to the prolonged action of " heated air (heat with liberal aeration), so as to expel a certain " amount of its water without the formation of gluten or the " coagulation of its albuminates. This end is achieved when " the temperature does not exceed 100° Fahr. When the malt " is sufficiently air-dried, the air-passages are closed and the " malt is subjected to the action of radiant heat. The remaining " water, which is difficult to get rid of during the preliminary " process, is thus expelled, and an important change " is effected in the constitution of the malt by the splitting up " of its albuminates and the formation of peptones. The same " results were formerly sought in the old-fashioned smoke-kilns " by direct application of strong heat produced by the combustion " of split-beech logs, whereby the last traces of moisture " were expelled, and certain kiln-products elaborated in the malt, " but with an expenditure of trouble wholly disproportionate to " the results attained. Now, the application of radiant heat " allows the same effects to be produced without difficulty. " The character of beer thus depends much on the method " of drying the malt adopted."

This is also confirmed by Marx, who states,* " As a rule, it " may be affirmed that malts which saccharify slowly give " worts poor in sugar.

" The sugar in the wort is determined by Reischauer's " method. By numerous observations and discoveries which " have been made at the laboratory at Weihenstephan, it has " been found that the best beers, and those which kept the " longest, were produced from malts which had given 65 to 69 " per cent. of maltose in the extract—that is, a ratio of " maltose to non-maltose equal to 1:0·41—1:0·54. The " complaints of secondary fermentations, of the want of head " on the beer, of the frequent troubles arising from *saccharomyces " exiguus*, belong to the malts of which the ratio of the " maltose to the non-maltose at the laboratory has been found " below 1:0·48, while slow fermentations, bad secondary " fermentations, the difficulty of yeast settling in the vat, the " bad keeping qualities of the beer, are due to the surplus of the " non-sugar in the malt.

" The time of solution and the exact ratio of the maltose to " the non-maltose *can only be obtained by proper manipulation " in the drying*. The essential condition for arriving at a " good result is to dry the malt slowly. Kiln-drying must

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* Translation in the *Brewers' Guardian*, 1884.

" never be hurried, for it is a great fault to dry the malt too " rapidly. Green-malt ought not to be too suddenly exposed " to the heat; it is to be dried at a low temperature, and " only when it is dry, and contains a small quantity of " moisture, may the temperature be raised and the last heating " be given. Let us see what happens, if, in wishing to dry too " quickly, the temperature is raised too soon. It is known " that in kiln-drying a great part of the diastase is destroyed. " The discoveries of Kjeldahl tell us that notwithstanding the " most careful kiln-drying, more than half of the diastase was " destroyed. But this loss of diastase is not produced by a " high degree of temperature in the drying, but from the " quantity of water still contained in the malt when it reaches " this high temperature. In presence of water the diastase " coagulates; if, then, you heat too much, before the malt has " attained a certain degree of dryness, a great part of the " diastase will be coagulated: the result will be a want of " converting power in the malt, and consequent slowness in " saccharification and the bad ratio of the sugar to the other " constituents of the wort. On the contrary, when green- " malt has become nearly dry and hard, the temperature may " be raised above 176° even to 212° Fahr., and the " diastase, being in presence of only a small quantity of water, " will not be destroyed.

" Malts which have been dried too quickly cannot be " employed for brewing. Indeed, their complete saccharification " cannot be obtained if the fermentations are slow, and the " clarification of the beer is with difficulty, if not incompletely, " brought about. It has been always remarked that malts " which are dried slowly on the upper floor of the kiln " saccharify better, and yield a better ratio of sugar to non- " sugar than malts which are dried too quickly.

" On the torrefaction depends also the character of the beer, " that is, whether it is vinous or dextrinous. To have vinous " beers with high secondary fermentations, the green-malt " must be dried at least from ten to twelve hours with strong " draughts of air at a temperature of 95° to 104° Fahr., then " continue the drying below 111° Fahr., until the grain become " dry. For Bavarian beers—that is to say those having palate- " fulness, the temperature is raised above 111° Fahr., when " the grain is hard, but not quite dry."

These temperatures are good, but the time for attaining dryness is insufficient. A leg of mutton cannot be boiled satisfactorily in ten minutes, and the cooking influences exerted upon malt in a kiln require a certain period of time *plus* certain conditions of heat and humidity. Change any of the factors, and the result is changed. So far as experience yet teaches, rapid drying of malt is not beneficial. Directly it is found to be good, let us by all means adopt the American style of kiln and mechanical movement of air through drying malt. Rapidly-dried malt is always more hygroscopic than that dried slowly. I believe eventually it will be proved that the chief power of stability in English beers is largely derived from the treatment of the drying grain in kiln.

Professor Graham has published tables showing some of the influence of kiln-heats on the composition of wort, by which it is seen that an increase of temperature increases the proportions of dextrine, but reduces the amount of extract and acid, and alters the proportion of sugar and soluble albuminoids.

Influence of High Kiln-heats on Infusion-products of Malt.[*]

	194° Fahr.	212° Fahr.	248° Fahr.
Maltose	57·01	52·44	51·32
Dextrine	14·92	18·49	19·35
Lactic acid	0·56	0·49	0·31
Soluble albuminoids	2·09	1·60	1·50
Colouring matters, ash, &c.	1·49	1·38	1·32
Total dry solids	76·07	74·40	73·80

Dr. Graham's experiments have been confirmed by Kjeldahl, who proved by his experiments in the Carlsberg laboratory that in the process of malting there is no appreciable increase in the diastatic power of barley till the third day on floor, and that it is during the fifth and sixth days that the greatest change is observed. After that time the development again slackens. Kjeldahl found that the diastatic power of malt before kiln-drying is about three times as great as that of the barley from which it is made, and that during kiln-drying a retarding action takes place, so that the fully-dried malt has then only about 25 per cent. more diastatic power than the original malt.

Brewers who make the malt they use are much more interested in the question of thorough and perfect drying than maltsters who make it for sale. By very complete curing, malt is not often improved in appearance, nor is the bulk increased, and it requires the exercise of considerable faith to believe that the increased appreciation on the part of users compensates for the direct loss incurred.

When brewing has progressed a little beyond its present stage, it is possible that appearance of malt will be totally disregarded, and that the essential qualities will be alone considered.[†]

A question of far greater importance than appearance is the true value of the empyreumatic flavours given to green-malt by direct contact with the products of combustion. Our English system of firing invariably gives this. Dr. Graham says concerning it:—

" So far from considering the English plan of allowing the
" products of combustion to go directly through the kiln-tiles
" a bad one, I consider it is an advantage. It smokes the
" barley, which, like a Finnon haddock, keeps the better for it.

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[*] Dr. C. Graham, on Lager Beer, *Soc. Chem. Ind.* 1881. See also his Cantor Lectures, *Journ. Soc. Arts*, 1874.

[†] Fifty years ago it was a very usual thing for the estimable quality of boldness to be fictitiously given to malt by sprinkling water upon it after it was thrown from the kiln.

" This empyreumatic creosote-action is continued in the after-" process of mashing and fermentation, and I therefore think " that, so far from the foreigners being justified in abusing the " rough way in which English maltsters work, they deserve " praise."

Unfortunately our knowledge makes it at present very difficult to determine the true nature and value of these influences.

RE-DRYING MALT.

Owing to the absurd modes of storing and keeping malt still practised, a very large quantity of malt absorbs sufficient moisture to become distinctly slack or clung (called also " Thane-malt ").

To prevent the necessary mischief that results from attaining disastrous influences, and to make the malt usable, it is customary to re-dry it.

Steel, in his most modest manner, says of this,* " So much " has been said of the curing of malt that it is scarcely neces-" sary to add anything on the subject of re-drying when a " brewhouse is not doing well, but the practical men are so " stupid or lethargic, and the master-men sometimes so falsely " economical, that it had better be strongly put that 'Thane' malt " being in ninety cases out of one hundred the cause of bad " beer, re-drying is the cure (the only), and a never failing " cure. Some parties argue that re-drying does not take away " acid; perhaps so, but it destroys, at all events, acid ferments, " and evaporates off some of the free acid, and the little free " acid left does no harm to a brew."

Mr. Faulkner† says—very truly,—" Slackness means the " presence of an excessive moisture-percentage, and, under the " influence of this, the azotised constituents soon drift into a " very abnormal or diseased condition, and become unsuited " to act as a support or aliment of the ferment we afterwards " cultivate. Re-drying stops for a time the action specified, " but does not restore the character of the nitrogenous bodies."

No amount of re-drying can ever make clung-malt sound and really good. It is, however, invariably the result of gross carelessness or want of knowledge if malt gets slack.

Malt intended for lager beer must be carefully heated upon the kiln, and not exposed suddenly to any great amount of heat. Improper regulation of temperatures in drying causes the resulting fermentations to be unsatisfactory. Inferior malt and irregular fermentations do not often produce satisfactory beer. Continental malt is usually spoilt by being dried too rapidly, forty hours being the outside time allowed, and more frequently much less. The injurious effects of this are much diminished by the system of mashing (decoction-mash), and especially by the low temperatures at which the beer is fermented and stored.

Malt dried as in England with the full amount of empyreumatic flavour is preferable for lager beer. The modes of drying malt in the chief centres of lager-brewing confirm this, for Bavarian beer is more generally preferred by visitors to the Continent. Bavarian malt is usually dried by loading the kiln fairly thick (about eight inches) when it is air-dried by means of a tolerably strong current of air at 88° Fahr.; the ventilators are then closed, and heat with little air allowed to pass through the grain, so that the temperature, in the course of a couple of hours, rises to about 170° Fahr. when the desired cooking processes are completed. The resulting darkening of the endosperm of the malt has been but little studied. It may be assumed that the albuminates, the peptones and parapeptones, together with the extractive matters and resins in the husk, share in its production, as well as the natural caramelisation of starch, when still moist at such temperature. The main point is to sufficiently prolong the kilning-off, as the longer the malt is subject to heat in the absence of aeration the better adapted it becomes for the production of Bavarian beers.

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* J. STEEL, Malting and Brewing, p. 25.

† Theory and Practice of Modern Brewing, p. 23.

After drying in this way, the air-passages still being kept closed, the temperature is raised to 190° Fahr., and is so kept drying-off for two or three hours at the least. At this temperature the malt-aroma is produced, and is found to be more pronounced in proportion as the action of the heat and the exclusion of the air have been more complete. The substances which produce this aroma have not yet been separated. The drying is chiefly carried out on the lower floor, and occupies at least eight hours altogether. The time may be shortened by a very powerful draught, but in that case the drying-off will be incomplete, and the malt will be merely dried. When so dried it is unsuitable for the production of Bavarian beers.

The paler Bohemian beers are prepared from malt dried solely by hot air, lying on kiln at much less depth. The green-malt is exposed to a strong draught at a heat of 90° to 100° Fahr. until it is nearly dry, when it is raised to 120°, and rarely or never exceeds 125°.

In Vienna the drying very closely resembles the Bavarian plan, the malt being finished at 185° to 190°.

The following simple instructions to work a Stopes' kiln are sufficient to direct any intelligent man:—

Green-malt to be loaded on *top floor every time when fit for kiln.*

Heats to be kept—

First day, not below 80° or above 100°.
Second „ 90° „ 110°.

After two days, lower top floor to bottom.

Third day, heats from 120° to 130°—140°.
Fourth „ 140° to 185°—195°, or more.

Top floor can be *ploughed* or forked over lightly if needed, and heats can be raised or lowered, according to the character intended to be given to the malt.

Bottom floor *need not* be turned or ploughed.

The regulation of heat and air to be effected by due attention to fires, or adjustment of air-inlets and dispersers.

When floors are young and green, dispersers can be closed and inlets open. Air is required at this stage.

When the bottom floor is to be finished off at high heat, air can be supplied moderately and dispersers opened.

By these means the bottom floor can be 190°, and top floor 100°.

Sweating of barley to be upon the most convenient floor (preferably the bottom one). Heat of sweating not to exceed 115° when top floor is loaded.

The diagrams, Figs. 146, 147, show this in a graphic form.

The best arrangement for recording the heats of kiln, and, indeed, the whole process of malting, is illustrated in the Appendix, together with a good form of record-sheet, kindly furnished me by Messrs. Smith and Eastaugh, Beccles.

The table of heats, p. 389, conveys a very large amount of information to a thoughtful mind.

Pneumatic malt is dried in all respects similarly to that grown on ordinary open floors. Should it reach the kiln-floor in a less dry or withered state, then greater care is needed to regulate rightly the heat and draught. Otherwise no difference is necessary in drying.

The whole of the preceding remarks in this chapter refer to pale malt only. "Patent" or black, amber, brown, and blown malts, and the varying conditions essential to their production, I have already sufficiently described in Chap. XII., pp. 158—175.

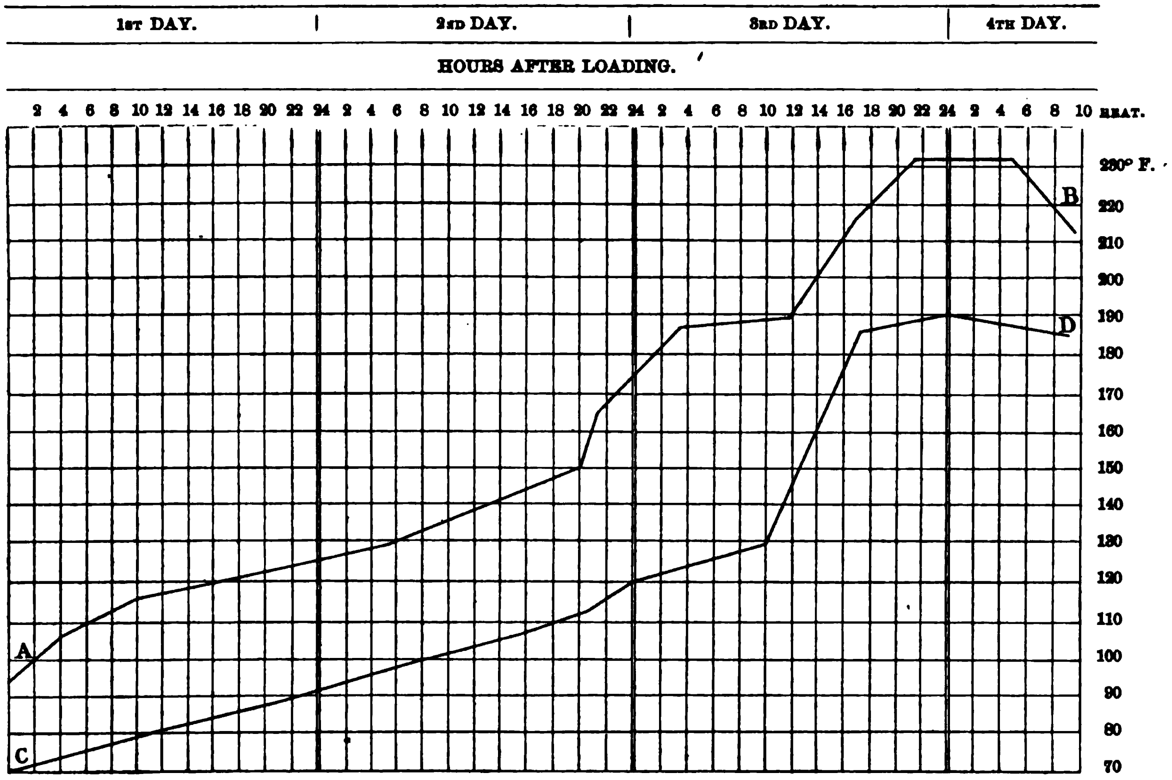

FIG. 146.—DIAGRAM OF SAFE HEATS FOR PALE MALT. A B, MAXIMUM, C D, MINIMUM HEAT.

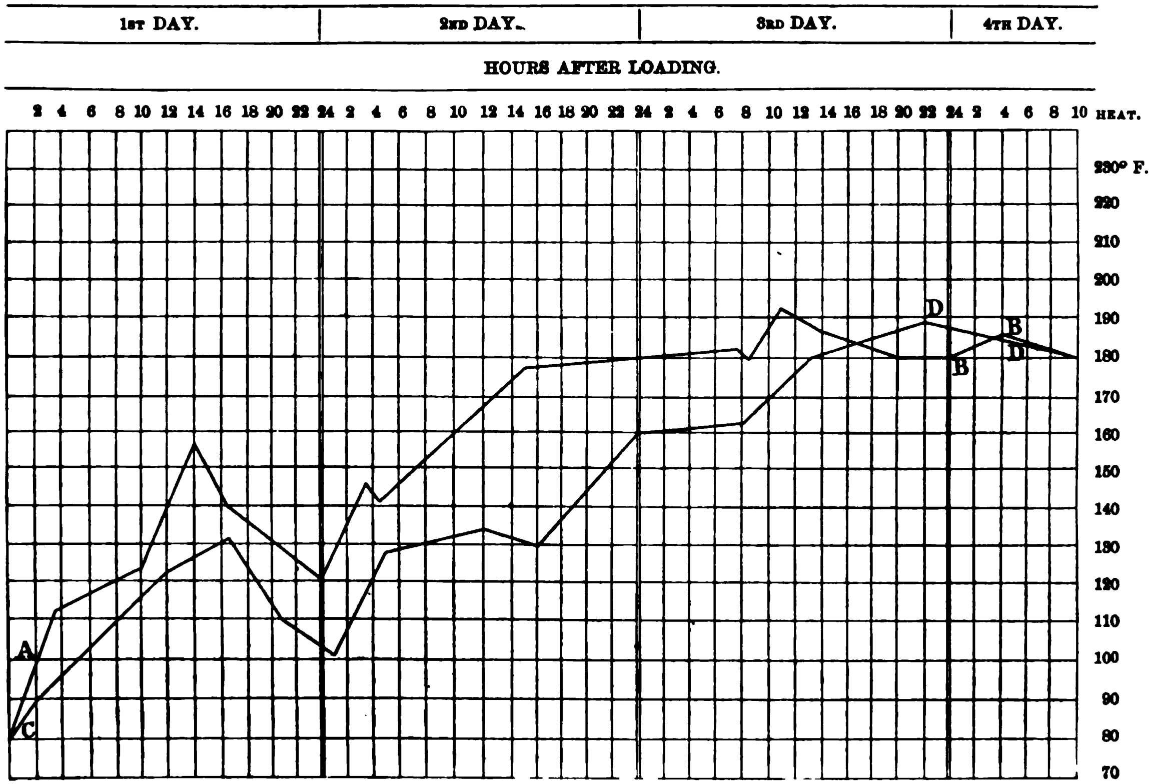

FIG. 147.—DIAGRAM OF HEATS OF MALT. A B, 1 INCH BELOW SURFACE: C D, IN CONTACT WITH TILES.

Table of Heats Approved by other Authors.

	Sweating.	Cistern.	Couch.	Floor.	Withering.	Kiln.				
						1st day.	2nd day.	3rd day.	4th day.	Finish.
	Degrees.	Feet.	Feet.	Feet. *		Degrees.	Degrees.	Degrees.	Degrees.	Degrees.
Champion * ..	—	—	—	48—54	—	{ 90 { 80	100—110 88— 92	120 98—104	110—120	120
Combrune † ..	—	—	—	—	—	—	—	—	—	129
Faulkner ‡	100—120	—	—	—	—	110—120	120—150	150—160	180—200	200
Ford §	120	—	—	50—48	—	100	—	—	130	135
Hooper ‖	80—120	—	—	60	—	120?	—	—	—	140
Paul ¶	—	59	50—59	—	—	—	—	—	—	212
Roberts **	—	47—50	—	50—48	—	70	—	—	—	140
Steel ††	120	50?	37—47	50	—	{ 100—120 { 100—120	150—160 —	170 —	— 160—170	— 170
Steiner ‡‡	—	50—55	—	50—60	—	90	135	145	190	190
Thausing §§ ..	—	34	56—65	54—77	—	120	167	—	—	167
Thomson ‖‖ ..	—	—	—	—	—	90	—	—	—	140
Tizard ¶¶	—	—	—	50—56	—	80—84	84—99	95—98	120	120

The heats that may be adopted with more or less safety under normal conditions are as follows:—

Sweating.	Cistern.	Couch.	Floor.	Withering.	Kiln.				
					1st day.	2nd day.	3rd day.	4th day.	Finish.
110—115	50—56	50—60	50—65	60—95?	80—85	90—95	100—120	160—230	220

Reynoldson, Black, Wigney, Morrice, Levesque, Baverstock, and other writers, either omit all reference to heats, or speak in a vague and useless manner upon the subject. It is very difficult to ascertain what heats the majority of writers recommend.

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* W. Champion, The Maltster's Guide.

† M. Combrune, Theory and Practice of Brewing.

‡ F. Faulkner, Theory and Practice of Brewing; and Occasional Notes, *The Brewers' Journal*.

§ W. Ford, Practical Treatise on Malting and Brewing (1862).

‖ E. G. Hooper, The Manual of Brewing.

¶ B. H. Paul, Industrial Chemistry (Payen's).

** Roberts, Scottish Ale Brewer.

†† J. Steel, Malting and Brewing.

‡‡ I. Steiner, *Brewers' Journal*, 1883.

§§ J. E. Thausing, The Theory and Practice of the Preparation of Malt, &c.

‖‖ T. Thomson, Brewing and Distilling.

¶¶ W. L. Tizard, The Theory and Practice of Brewing.

CHAPTER XXI.

FINISHING AND STORING.

Finishing and Storing :—

Methods of Treading and Screening. Removal of Combes. Dressing Malt. Storage. Opinions of Thausing, Steiner, and Steel. Absorption of Moisture. Quantity of Combes produced. Changes in Malt. Aubry's Researches. Sprinkling. Storage in Carbonic Acid. Changes in Weight and Volume by Malting. Weight of Malt. Transit.

Mould. Causes of Mould. Atmosphere. Corn. Bacteria and Moulds. American Treatment of Corn. Brejcha's Views. Broken Corn. Unclean Cisterns, &c. Bad Floors. Mixture of Corn. Infrequency of Steep. Poupé's Views. Huxley on Bacteria. Impurities in Water. Varieties of Mould. Mildew. Prevention of Mould. Ventilation. Antiseptics. Conclusion.

MALT when dried has yet to undergo further treatment to fit it for use, unless it is to be employed as food for animals.

This treatment varies according to circumstances, and is ruled by the final disposal of the malt.

Pale malt for all purposes, and all malt for brewers' use, has to be freed from the radicles or combes,[*] and otherwise cleaned.

When cleaned it is requisite to store malt for a short period, and it is then fit for sale or use, and passes from the maltster's charge.

The finishing processes are few and simple.

After the floor is finished off on kiln by maintaining it for a certain length of time at a given temperature, maltsters differ as to the performance of the next step. This widely varies according to locality.

The plans adopted, known to me, are as follows:—

The kiln-floor is at once vigorously trodden by men having heavy boots, and in some cases they are provided with clog-treaders, *i.e.*, a wooden sole or clog, having a series of six or eight steel blades, similar to skate-blades, securely affixed. This treads off the dried radicles, so that the malt by simply passing over a water-fall malt-screen is commercially clean, and fairly freed from dust and combes.

Or the malt is heaped up in centre of floor, and remains for a night untrodden, with the fire well banked.

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[*] **This I find variously spelt, and called, combs, combes, comes, comings, cornings, cumings, and cummings, chives, germs, roots, rootlets, radicles, tails, tailings, or sprouts.**

Or the malt is at once thrown from kiln and heaped on floor of adjacent store prior to treading. This is done at any convenient hour during the two or three days following, when it is trodden and screened.

Or it is taken straight from kiln-floor to malt-bin or store, and is not trodden, screened, or done anything to until it is required for use.

On the Continent it is passed at once through a rotatory screen, having a series of knives working in the conical receiving-hopper, which effectually knock off all combes, &c.

If malt is dried at too low a temperature the rootlets are very tenacious, and cling toughly to the grain. They have not been dried sufficiently to become brittle, and the ordinary treading is insufficient to remove them. With very high-dried malt they readily break off.

The colour of the combes furnishes a better criterion of the heat at which malt has been dried than the malt itself.

Considerable difference of opinion exists amongst practical maltsters as to the desirability, or otherwise, of removing the combes from malt intended for long storage. Some contend that it is good, others assert that it is bad. There should be no difference of opinion, for it is patent to everyone that combes absorb moisture with greater avidity than whole pale malt. Consequently, when the condition of the air in store is humid and bad, the combes readily and freely absorb moisture. They become wetter than the surrounding malt. When the air is drier the combes impart their moisture to the malt, and accordingly the malt is drinking in wet, when if the combes were away it would not do so. As a consequence, the percentage of moisture in the malt after long storage will, in nearly every case, be greater when the combes are left unscreened than would be the case if they had been removed.

If the malt is screened and placed in bulk, with all exposed surfaces covered with 8 in. or a foot of combes, and all draught excluded, it will remain for months and not gain one per cent. of moisture (in addition to that left in at finishing).

Dressing malt concerns brewers and users more deeply than maltsters. It is simply a final process exerting but slight influence upon the character of the product, and whether done well or ill is comparatively immaterial to the maltster in many senses.

The majority of brewers look upon it in the same light, and many use very ill-dressed malt without further screening. If, however, any sensible man reflected carefully, and brought a microscope to his aid to determine what he passed into his worts and beer, by so doing he would speedily arrive at the conclusion that very considerable cost in fixing screens and cleaning appliances would be speedily repaid.

Curiously enough, 500 years ago, this very question was deemed of sufficient importance to require special legislation, and an Act was passed (17 Richard II., c. 4) which remained unrepealed till 19, 20 Vic. (1856), compelling maltsters in the home counties to thoroughly dress their malt, under heavy penalties; and frequent laws followed to similar effect.

To maltsters who are also brewers, the question of proper storage of malt is one of very grave importance. The two deadly foes that must never be forgotten for a single instant are weevils and moisture. Protect malt from their ravages, and all is well.

It must not be overlooked, however, that protracted storage of malt, even in absolutely air-tight metallic bins, is not good; for the malt-constituents, especially the albuminoids, and indeed all those that exert a direct influence upon the character of the beer, are particularly unstable and susceptible to change.

The most satisfactory equilibrium of the constituents of malt is reached in a month or six weeks after drying, and it changes within two months. No malt is ever so good after three months as it has been. I hardly believe it will ever be possible to make long-stored malt equal to that properly treated when two months old, not even when malt-bins are scrupulously kept filled with carbonic acid gas.[*]

Steiner says (and he is right)[†]:—

“ Malt direct off the kiln, however carefully dried, is not “ suitable for immediate use in the brewery; as, unless it be “ kept for from five to seven weeks in store, the worts produced “ from it do not break well on boiling, the fermentations are “ irregular, the yeast deteriorates, and the resulting beer “ remains cloudy for a considerable time. Krandauer has “ shown that during storing, part of the originally soluble “ albuminous matter becomes coagulated in the corn, whilst, “ at the same time, gradually less maltose and more dextrine “ is obtained in mashing. On the other hand, although it is “ advisable, for regularity of produce, to procure a good stock “ of malt, if it has been kept too long it loses in value. Not “ only the flavour of the sample changes, but it gradually “ becomes slack, *i.e.*, the percentage of moisture increases “ from 2 per cent. (at the commencement of the season) to “ 5 or 6 per cent., when the beer produced from it will remain “ cloudy and does not keep well.”

Steel advises placing malt in open bins, well covered with combes, and when removed, should any of the malt be slack it should be re-dried. He says also[‡]:—“ Of course in long rooms, “ with the malt open on the top, skimming may go on from “ day to day as the malt is abstracted; and there cannot be a “ better method of storing, proper skimming being attended to.” As Steel considered re-dried clung-malt equal to crisp-malt, he thinks he is right, but re-drying malt is a great nuisance; it necessarily costs labour and fuel, and it is simply impossible for any malt to get clung without direct injury, capable of very easy demonstration.

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[*] THAUSING says, “The age of malt has no influence whatever upon the quality of the beer.” This is a very extraordinary statement.

[†] The Principles of Malting, *Brewers' Journal*, 1883, pp. 86—91.

[‡] Malting and Brewing, p. 27.

Mr. Steel does not state how deeply he "skims."

The power of moist air to penetrate into a heap of malt is much greater than is commonly supposed. Thus, in a bin free from draughts, and covered with 8 in. of combes, I have found, after six months storage, the percentage of moisture to range as follows:—

Original percentage of moisture in malt after drying	3·0 per cent.
In the combes on surface	14·2 ,,
Do. next malt	12·5 ,,
Malt on surface of bin	9·5 ,,
Do. 6 inches deep below combes ...	7·2 ,,
Do. 12 ,, do. ...	6·3 ,,
Do. 2 feet do. ...	5·1 ,,
Do. 3 ,, do. ...	4·5 ,,
Do. 4 ,, do. ...	3·8 ,,
Do. 5 ,, do. ...	3·4 ,,
Do. 6 ,, do. ...	3·2 ,,
Do. 7 ,, do. ...	3·2 ,,

Apart from the hygroscopic character of combes, it is necessary to remove them from malt intended to be brewed, because of the composition of the soluble constituents. These add very materially to the colour of pale-worts, and give a harsh bitterness that is most objectionable. The excess of nitrogenous matters also render only a small quantity of combes in the mash-tun positively harmful to the beer in most cases. (See pp. 175, 176.)

The average quantity of combes screened from malt is about 5 per cent. on bulk, and 3½ to 4 per cent. by weight. This is necessarily very much ruled by the growth of corn on floor, and to a less extent by the degree of drying. A very lightly grown corn may yield as little as 2 per cent. by weight of combes.

The construction of storage-bins has already been explained. (See p. 222.)

The character of the changes that are effected in malt by storing, are very inadequately understood, and require much more careful research to determine or elucidate.

The following remarks by Aubry possess great interest.*

The composition of the same malt was determined immediately after drying and after seven months' keeping, when the supposition that it had become modified during storage was confirmed in the case of the nitrogen and sugar percentages of the extract, which were found materially reduced.

In malt dry-substances:—

	Fresh. Per cent.		Stored. Per cent.
Extract (Balling)	77·91	...	77·72
Maltose	54·83	...	50·07
Nitrogen	0·623	...	0·489
Other proteids	3·90	...	3·06

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* *Jahresbericht k. centr. Sch. Wiehenstephan*, 1882.

In extract:—

	Per cent.		Per cent.
Maltose	70·38	...	64·44
Nitrogen	0·800	...	0·630
Other proteids	5·00	...	—
Maltose to non-maltose = 1	0·42	...	0·55

Aubry has also observed that malt drawn fresh from the kiln, when placed after cooling in a closed vessel into which air devoid of carbonic-acid was led, gave off considerable quantities of that gas. For two days air was led constantly into the vessel, after having been deprived of its carbonic acid by means of soda-lime and barytes-water; and as the malt continuously gave off fresh supplies of the gas, this leads to the supposition that either chemical changes, accompanied by the formation of carbonic acid compounds, were in progress in the malt, or that malt has a great capacity for retaining carbonic acid, which afterwards is gradually liberated.

The plan of making one large bin of unscreened malt, retaining all the combes, and running ventilating pipes through it in all directions, is most objectionable. It is done to attract and carry off excess of moisture. It would be equally sensible to keep a lot of rats in a cellar full of cheese to protect it from mites.

The practice of wetting malt after it leaves the kiln cannot be too sternly deprecated.

Lintner[*] says:—" It has been clearly demonstrated that the " chemical changes which take place in malt do not keep pace " with the physical modifications. Malt can be given a definite " humidity by sprinkling or by keeping it in a damp place, " without the changes which take place in it during storage " being in any way anticipated or furthered thereby. Chemical " changes progress gradually whilst the malt is kept. Heat " and moisture assist them; but it has been proved that the " more gradual the progress of these changes, the better will be " the quality of the malt."

Probably the perfection of malt-storage will be cylindrical bins, of small diameter and great height, kept filled with carbonic-acid gas. If these have conical bottoms, delivering into elevators or screws for removal of their contents direct to mills, and are fitted at top with air-tight receiving-valves, open only when malt is passing into them, probably malt may be kept six months with only slight injury and loss.

Before all this happens, possibly men will determine that it pays best to work pneumatically, and accordingly malt will be always supplied to the brewery of uniform age.

The changes in weight and volume of barley while being malted have been very carefully estimated by numerous writers. Thus Dr. T. Thomson, after a very elaborate series of experiments, found that the real loss barley sustained was 8 per cent. This he accounted for as follows[†]—

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[*] *Zeitsch. Gesammt. Brauw.*, 1886, No. 12.

[†] Brewing and Distillation, p. 31.

Carried off by steep-liquor	1·5 per cent.
Dissipated on floor	3·0 „
Roots and dust	3·0 „
Waste	·5 „
	8·0

In addition to this, barley ordinarily contains about 12 per cent. of water, which is driven off in drying malt; consequently dry malt averages from 78 to 82 per cent. by weight of the barley from which it is made.

Commonly, there is no decrease of bulk in malting barley; more generally there is a distinct gain, as, in common seasons, 100 bushels of dry barley yield 103—112 bushels of screened malt.* Very thin, dry, foreign corn will increase still more than this. Very dry English barley increased 15 per cent. in 1884. Bigg loses much more weight and measure than barley when malted.

Good malting-barley, well malted, now gives for each 100 parts by weight very much the same amount as determined by Dr. Thomson.

In an average sample, containing 13 per cent. of water, we have 87 per cent. dry material.

Throughout the malting processes of such barley we should find the following weights and volumes.

100 parts would weigh 100 and measure 100.

	Weight.	Volume.
Dry barley, as sold and delivered, but *well* screened	100	100
Water in same	12	5·
Barley in cistern, loss in swimmings	1	1·12
Steeped barley, commencement of couch	150	120
Do. end of couch	149	125
Green malt, fit for kiln	120	195
Dry malt, finished at 220° Fahr.	84	113
Water in same	2·5	—
Combes and dust in same	3	5
Dry malt cleaned (*no* moisture left)	79·5	108

The loss by malting averages—

Swimmings	1—2
Loss in steep	1—2
Losses on floors—gas, water, rootlets, etc.	4—9
Loss drying and screening combes, &c.	3—5

These weights and volumes are necessarily largely influenced by the quality of the barley, and especially by the care with which it is screened prior to steeping, and the final amount of water left in the malt when dried.

With high heat in steep, and on floors, but low drying and finishing heats, it is possible to lose as much as 14 or even 15 per cent., but such working would be disastrous in every sense.

Few fallacies can be worse than the purchase of malt by weight. A thoroughly malted barley, which is extremely heavy as barley, is naturally valuable as malt; but to suppose that therefore any other malt of the same weight is of equal value is simply absurd.

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* For fuller details, see Thomson's tables, *ibid.*, pp. 35—41.

Malt should be bought as malt, with its percentage of unmalted grain, water, and rubbish determined. Let these three all-important factors be first ascertained, and then see how much malt is left, and value it accordingly. To pay an extra price for malts weighing over 42 lbs. per bushel, when they acquire that weight under false pretences, is worthy of the Middle Ages. All users of malt should now be centuries in advance of such a practice.

TRANSIT.

It is still the custom in several large brewing centres for brewers to buy malt, or to have it made on commission. Were brewing a worse business than it is, this might be found to possess sundry disadvantages that would ensure a discontinuance of the practice. The financial and other disadvantages do not concern me; I must, however, point out the grave injury any malt sustains in transit, and in many cases bought malt has to travel long distances.

Malt, when placed in still air containing moisture, and in fairly dry air if in rapid motion, drinks in water. Consequently no malt can perform a railway or canal journey, or sea-voyage, however short, without imbibing some water. No such access of water can, under any circumstances, fail to affect the malt, and in most cases positively to injure it.

Barley is injured by transit less than malt if it is preserved from heating. Therefore it is better to carry barley to or near the brewery, and malt it there, even allowing for the 20 per cent. extra cost of freight, should it amount to so much.

English air is always humid, and a truck-load of malt, flying through a thick fog, or standing about one, two, or more days, on a bleak railway-siding, drinks in sufficient wet to seriously imperil the stability of any beer brewed from it.

When brewers discover what the addition of 3 per cent. of water does to the soluble albuminoids of malt, the practice of shifting malt any distance exceeding 10 miles, will be as rare as the old bugbear to our fathers of fox in worts is to the more intelligent race of men, who now find that fox and cleanliness are impossible in the same place. Sound beer and lengthened transit are equally antagonistic.

MOULD.

The ravages of mould, and references to its causes and cure occur frequently in this book.

Steel says* "all vegetable matters in a stagnant atmosphere "will degenerate into fungus." This statement was presumably intended to point out the prevalence of mould under favouring circumstances.

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* J. STEEL, Malting and Brewing, p. 14.

Up to the present moment this subject has not received much careful consideration from English maltsters. Comparatively few have ever taken the slightest trouble to prevent the starting of mould, or to check its development.

Mould, when existing on or in malt, is not only capable of influencing, very materially, the mash and wort prior to boiling, but its baneful effects are exerted after any length of boiling, both in gyles and finished beers. This is, consciously or otherwise, one of the main reasons why the best brewers, who have a reputation for pale and stock ales, pay such strict attention to the quality of the barleys they purchase. Yet it is no infrequent thing to find men giving large sums for choice growths of corn of fine colour, but omitting to remove the damaged or broken kernels, never cleaning or washing the barley before steeping, using no antiseptics either in cistern or on floors, growing upon floors filled with cracks that harbour dust and filth of all kinds, and finally, drying-off upon kilns that are not rightly ventilated, where the green-malt is kept at 90° to 120° for forty-eight to sixty hours.

Many of these men, if asked to explain why two beers, brewed alike in every way, should present very different characteristics after six months' or a year's storage, would gravely tell you that "the air was different when brewing," &c., or advance fifty other excuses, all equally remote from the true cause—mouldiness of the malt.

The causes of mould are numerous, but may be grouped in the following order of importance:—

1. Atmosphere charged with germs or spores.
2. Broken or damaged corns.
3. Uncleanly cisterns, floors, walls, ceilings, etc.
4. Admixture of flinty with kindly grain.
5. Infrequency of change of steep-liquor.
6. Impurity of water used for steeping and sprinkling.

A little further examination of these causes will show how easily most of them can be altogether removed or greatly diminished.

1. ATMOSPHERE CHARGED WITH GERMS OR SPORES.

This, the chief cause of mould in malt, constitutes one of the greatest difficulties with which the maltster has to contend.

The spores of mould have been proved to abound almost everywhere, and in a vast variety of circumstances, indeed their ubiquity is only rivalled by their diversity. Each of the numerous forms known to fungologists has its favourite pabulum and its special conditions of development, and wherever these requisites coincide, that development commences and proceeds with great rapidity.

Barley, during growth or at harvesting, is constantly liable to become the basis of a considerable variety of moulds, and in unfavourable seasons the development of these is carried on in the stack. Skill and care on the part of the farmers can alone deal with the mischief at this stage, and hitherto their efforts, only rarely put forth, have met with but small success. It would be unsafe to predict how many generations will pass away ere farmers as a body will be able to take to market, and sell to maltsters, samples of barley absolutely free from mould.

Meanwhile, maltsters must minutely examine samples before purchase, rejecting such as are tainted, damaged, or mouldy. This scrutiny should be effected with the aid of a lens or microscope, and, though important at all times, is especially so after wet and trying seasons. The ends of the corn require the closest investigation, as affording crevices for spores to rest in.

In the malting season of 1879-80, when the quality of much English barley was inferior, Mr. G. C. Matthews observed the frequency of the so-called "red corns" on the floors of a malthouse where various English barleys were being worked. This appearance was due to a mould, which Dr. Hansen, of Copenhagen, determined to be either *Fusarium graminarium*, or some closely-allied species whose life-history had not been traced. To the maltster the appearance of these red corns is probably not unfamiliar, though they are only seen, in any quantity, during the malting of inferior barleys. The mould is chiefly at the germinal end of the corn, and exhibits a conspicuous crimson colour. To facilitate investigation, he cultivated the mould in various ways well known to fungologists. Different kinds of barley, including Saal, French, Chilian, and Californian samples, were treated, and yielded similar results, but in varying quantities. An examination of the accumulated dust under barley-heaps showed that the greater portion consisted of earthy matter, but, in addition, mould-spores, infusoria, and bacteria, similar to those obtained from barley, were found.

Mr. Matthews is of opinion that mould is developed to a great extent in steep. The growth of the mould, beginning at the germinal end, spreads towards the opposite end, the rate of growth being determined by the supply of nourishment from the interior of the grain, and this itself is determined by the extent of the injury the corn has received by crushing, etc. On some grains there is a very slight colouration, whilst others are covered by a crimson paste, from which fungoid tubes are seen to emerge. The grains which are subsequently the worst affected are just distinguishable amongst the dry-stored barley, but many others that look like idlers develope the mould when on the floor. It is not, however, until they have been four or five days out of steep, that their presence is capable of being readily observed, without a good lens or microscope. From this period to the time of loading kiln, the mould grows with varying rapidity. The affected grains are nearly always incapable of proper germination, having been injured by heating in the stack and sprouting, or by being split or crushed during the thrashing. They are usually discoloured, misshapen, and indicate by their appearance that they are defective or devoid of the first essential—vitality. Occasionally in such grains an abortive growth takes place; one or more sickly, brownish-looking rootlets may appear, whilst the acrospire remains almost inactive; in others the reverse occurs, the acrospire growing to some length, the rootlets scarcely appearing, having been shrivelled up during an earlier sprouting. Such are the grains which are found with this particular mould developed in or upon them. The mould is never seen on a healthily-germinating, perfect grain. The red mould does not spread from grain to grain except where injured grains lie for some time in contact. This may be due to the supposition that the spores are not disseminated like those of common moulds, owing to their greater weight and their tendency to adhere to their original food-bed. Grains seriously affected with mould may generally be distinguished in finished malt by the colouring matter adhering to them. Mould-spores have an undetermined influence in the mashing process, and are not yet proved to be destroyed during the boiling in copper. Therefore any malt containing red grains must be of inferior quality, having been prepared from an indifferent sample of barley, besides which the mould-growth will have acted in a prejudicial manner on the constituents of the grain, using up carbohydrates, improperly affecting the proteins, and exerting other influences hinted at by me (p. 175).

Together with, but it would seem in numerically inverse ratio to, the mould-spores, the air contains the germs of the lactic-acid bacteria, and allied forms. Both germs and spores require moisture and slight warmth for their development, and in the absence of these conditions, their vital powers may apparently remain dormant for an indefinite period. But Professor Tyndall has shown that when once life has passed from the potential to the actual, a change of conditions that would not affect undeveloped germs, speedily destroys such as have begun to live. An infusion of six-year-old hay requires boiling several times before final sterilization is effected, successive series of germs awaking to life in the intervals and perishing by the heat. Pasteur, Hansen, and other distinguished men have experimented on the same subject with results of the highest importance, more especially to the questions of preserving easily putrescible matter such as meat, milk, and fruit.

Miquel has succeeded in collecting and numbering the spores or germs of bacteria, and, while confirming Pasteur's observation, that they are always present in the air, has shown that their number presents incessant variations. Very small in winter, it increases in spring, is very high in summer and autumn, then sinks rapidly when frosts set in. This law also applies to spores of fungi and moulds; but while the spores of moulds are abundant in wet periods, the number of aerial bacteria then becomes very small, and it only rises again when drought pervades the soil, a time when the spores of moulds become rare. Thus, the *maxima* of moulds correspond with the *minima* of bacteria, and reciprocally. In summer and autumn, at Montsouris, Miquel frequently found 1,000 germs of bacteria in a cubic yard of air. In winter the number often descends to four and five, and on some days the dust from 200 litres of air was incapable of causing infection in the most unstable liquids. In the interior of houses, and in absence of mechanical movements raising dust from the surface of objects, the air becomes fertilising only in a volume of 30 to 50 litres. These results differ considerably, it is pointed out, from those published by Tyndall, who says that a few cubic centimetres of air will, in most cases, bring infection into the most diverse infusions. M. Miquel further states (in opposition to most investigators) that the watery vapour which rises from the ground, from rivers, and from masses in full putrefaction, is always free from germs; that gases from buried matter in course of decomposition are always exempt from bacteria, and that even impure air sent through putrefied meat, far from being charged with germs, is entirely purified, provided only the putrid filter be in a state of moisture comparable to that of earth at about twelve inches from the surface.

It is, however, manifestly difficult for a maltster to supply filtered air to his growing-floors as commonly constructed and used, and therefore his tactics in the warfare with mould must take the form of purification of his other materials; though he should of course allow no avoidable impurity to mingle with the air of his malting, by relegating dust-heaps, stables, cesspits, and the like, to points whence their effluvia are unlikely to reach the growing-floors.

All grain requires careful and thorough cleansing to remove germs and spores from its exterior. Screening, brushing and washing will get rid of much of the filth always adhering to corn, which furnishes nutriment to both mould and bacteria in the early stages of their existence. Not only is actual dirt thus removed, but many substances which might come under that category as "matter in the wrong place," such as seeds of other plants, broken, weevil-bitten, starved, or otherwise imperfect kernels, fragments of awns, &c., all of which even where not palpably detrimental, are distinctly out of place in good malt.

In America much more attention is given to cleaning and scouring barley than is the case in Great Britain. Before steeping, it is passed through sundry sieves and brushes, and if carefully examined it would be considered clean and free from mould-spores. But if a small quantity of this corn is placed in a sterilized bottle, with distilled water (which contains no spores whatever), and is left securely sealed against contact with air in a warm place, it is very speedily found that the water in the bottle perfectly teems with bacteria and a variety of moulds and other low organisms in various stages of development. If this experiment is conducted carefully, we can be perfectly certain that all this life, with its potential force, was dormant in or upon our corn, which we had previously deemed effectually cleansed from impurity.

If this is true of corn which has received such care and attention, what can be the result of steeping corn in all its filth, as we so frequently find even in maltings of large size, and belonging to men who are considered good maltsters.

In an interesting paper,* M. Brejcha remarks that, in the present day, innovations in brewing are many, but good original suggestions are few and far between. Among the latter must be reckoned apparatus for washing barley before malting. A thorough washing of the barley in the steep-cistern was once the rule; now it is the exception. Yet the advantages, especially with such barley as that of 1879, cannot be overrated. Harvested when more or less wet, the bulk of the grain was dirty and discoloured; and white-looking grain was scarce. The dark colour and fœtid odour of the water in which such barley was steeped, were sufficient in themselves to suggest inquiry whether they were the results of internal or merely superficial alterations in the grain. It is true that a proportion of the corns in such cases appear to be deteriorated internally; but there is every reason to believe that the causes of the peculiarities in the steep-water exist on the surface of the grain.

The water extracts from the grain certain salts, as phosphates and chlorine compounds, which can be detected by ordinary chemical tests; at the same time, it detaches from the husk a host of organic and inorganic impurities, the presence of which is apparent even to the unassisted eye, but which only stand forth fully revealed under the microscope. To learn something more than is generally known of these impurities, M. Brejcha made an experiment with 1879 barley, with the following results:—

The barley was first carefully blown and screened, so that the bushel averaged 54 lbs. Internally it was white and mellow; hard vitreous corns formed about 5 per cent. of the whole; the grains were of normal shape, with a barn-like smell, a brownish-yellow hue, and about 2 per cent. had well-marked dark tips. The water for testing was taken from a steep-cistern constructed of masonry, with a perfectly smooth lining of cement, and which had been well washed out with lime-water before use. The grain was thoroughly blown. On entering the steep-cistern water was kept running on it, which water was afterwards run off, and replaced by fresh at a temperature of 50° Fahr. Pure spring-water was used. After twelve hours' steep, the samples were taken, and the water again renewed. The water of the samples was dark-coloured, with much scum. In a glass it presented the appearance of beer brewed from a malt dried at 167° Fahr.; it was clouded with fine particles of matter; the taste was sour, the smell mouldy and offensive. Part of the water was hermetically sealed and put by in a dark cold place for further examination; and a small quantity was analysed at once. The microscope revealed, besides minute particles of various mineral substances, azure particles frequently found in running waters and in mashes, and which abound in Pilsener store-yeast, minute crystals of lime, fragments of diatom-cases, and particles of soil from the fields, large numbers of mould-spores of various kinds, and in all stages of development. When examined two or three days afterwards, the water was found to contain large numbers of bacteria—mostly sphaero-bacteria, with some desmo-bacteria and micro-bacteria. The same results were found in the hermetically sealed sample, but the bacteria were less numerous.

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* *Zeitschr. Brau-ind. Ver. Böhm.* 1879.

The mould-spores of various kinds, some colourless, some grey or greyish-brown, and some black, were so abundant as to fully account for the colour and evil smell of the steep-water. The same mould-spores and dark colour were observed in the water first run off from the steep-cistern. The microscope thus gave no startling results, but indicated clearly the importance of repeated renewals of the steep-water in conjunction with sufficient agitation of the grain to rub off the impurities and allow of their being washed away. Omitting all reference to the *character* of the water, M. Brejcha argues that there is no good reason to dread the consequences of too frequent renewal.

At one time a rain-stricken, high-coloured grain was considered best for malting; now the preference is given to a sound white grain; but, in M. Brejcha's opinion, it is yet an open question whether the former, if still soft and mealy, is not better than a hard, dry, white one. It was found that in 1879 barley had a proportion varying from 4 to 15 per cent. of the corns which failed to germinate altogether, although they appeared internally unaltered. Why this should be so when others, the points of which have become perfectly black, germinate freely, is difficult to explain. Perfect purification of the grain from all traces of mould is probably impracticable, but a very high relative degree of purity may be secured by attention to the following points:—Choice of the soundest grain procurable; thorough aeration of granaries; (with a like object the grain, especially when first stored, should be placed in shallow layers and frequently turned); thorough separation of all dust and damaged corns; thorough washing of the grain after, as well as before, it has begun to soften, accompanied by frequent renewals of the steep-water; suitable agitation of the grain during steeping, and the running-off of the water so as to secure the absolute removal of all impurities.

The washing should be done after the grain is screened, and before it enters the steep. A receiver, provided with a constant flow of water and some sort of rotatory apparatus or brushes, is all that is needed. The best arrangement is shown by Fig. 141, p. 315. The clefts in the corns are said to offer hindrance to perfect cleansing with the brush alone. The steep-cistern also has in some cases an arrangement of rotatory shovels, worked by hand or power. In conclusion, M. Brejcha records his belief that a careful washing of the grain before malting is a decided improvement, and a desirable acquisition to the art of brewing upon scientific principles.

2. Broken and otherwise Damaged Corn.

A prolific source of mould in malt is the proportion, often large, of imperfect kernels. These are incapable of growth, and the skin not being continuous, spores that settle on the exposed starch-granules or gluten-cells develope more rapidly than would otherwise be the case. The spread of mould in grain containing but a small percentage of broken corns is something marvellous. Idle corns, in which putrefactive instead of vital changes are taking place, are a source of trouble, by the production of lactic and butyric acids; but if the skin be not broken, they do not foster mould so much as the damaged kernels. Nor does the evil stop here, for though healthy men may pass intact through the most virulent contagion, mould, which is in many points analogous to the enzymes of disease, seizes alike on the finest and poorest kernels, when once they are brought into the same conditions of moisture and warmth on the floor, penetrating the starch-body with its mycelia and corrupting the whole bulk.

3. Uncleanly Cisterns, Floors, etc.

It is, of course, useless to purify the grain unless the cisterns, floors, walls, ceilings, and, indeed, every part of the malting be kept as clean as possible. Quicklime, carbolic and salicylic acids, permanganate of potash, sulphurous acid, and bisulphite of lime, all form excellent antiseptic washes, and the latter can be added with advantage to the steeping and sprinkling liquor, and also, upon occasion, to the floors at all stages of growth. (See pp. 46—48.) Cleanliness at the commencement of the season is good, but to insist upon its strict observation throughout the year is far better.

Irregularities and cracks in floors are particularly objectionable as harbouring dirt, enabling mouldy kernels to lie undisturbed in turning, retaining stagnant water, and generally promoting the development of mould and bacteria.

4. Admixture of Flinty with Kindly Barleys.

The direct connection between mould and the mixture of different growths of barley before steeping, does not lie upon the surface, and a little thought is needed to trace it. A harsh, coarse, rough growth of barley, that comes from a stiff clay or cold soil, requires a different period of steeping to that required by a small, fair-skinned, kindly barley, grown quickly upon a light soil. If the two are mixed together, and steeped in the same cistern, it is inevitable but that either one is insufficiently steeped, or the other is kept too long in the cistern. A practical maltster will usually prefer the former evil, for, in his opinion, it is the smaller—the portion that has been properly steeped grows duly, the oversteeped or drowned corn has its vitality materially affected—consequently it falls the more easily a prey to the contamination of mould.

Should the other course be adopted, then the imperfectly steeped kernels grow slowly and languidly, if they grow at all, and they also readily foster the growth of disease.

5. INFREQUENCY OF CHANGE OF STEEP-LIQUOR.

If liquor remains in the cistern sufficiently long to become fœtid, single spores of mould quickly propagate. The generation of the lower forms of minute life proceeds generally with startling rapidity. When liquor is left unchanged for a period of twenty to forty hours (which frequently occurs) the spores will have increased many thousandfold. Unless the barley and the atmosphere have been singularly pure, any long steeping must disseminate sufficient germs to cause much needless and easily-avoided trouble. Almost everyone knows by experience the rapidity with which yeast developes when placed in wort at a temperature of 90° Fahr. Although the increase of mould does not proceed quite so quickly, nevertheless it bears some analogy to yeast reproduction.

By frequently renewing the liquor in the cistern and well rinsing the corn, much of the mould is carried away bodily and its power to do evil is reduced.

Some such system is recommended in many of the old works on brewing, one of the writers (Poupé) going as far as to advocate steeping in running water. But whatever plan is resorted to, it will be evident that the present method of scouring grain dry and steeping in one or two waters, which are simply drawn off, leaving a large portion of the solid impurity with the grain, is an insufficient and crude process.

The other points in a malting connected with this cause of evil, which is, unfortunately, very prevalent, are more fully discussed in Chap. XIX.

Professor Huxley, speaking of river water at the Chemical Society, London, referred to the power of germs to produce disease. He showed that infectious diseases are caused invariably by bodies of the nature of bacteria. Bacteria are just as much plants as mushrooms or cabbages, so that we know under what conditions bacteria can live and what they can do. Bacteria can be sown in Pasteur's solution, just as mustard and cress can be sown in the soil. If one drop of Pasteur's solution were placed in a gallon of water, it is doubtful whether its constituents could be estimated, but every cubic inch of such water would contain 50,000 to 100,000 bacteria, and one drop of it could excite a putrefactive fermentation in any substance capable of undergoing that fermentation. This shows that chemical analysis is not always capable of detecting what may be really a deadly poison in water; and on the other hand, a sample of water may be chemically gross, but yet harmless to health. These remarks are especially applicable to diseases affecting the human body, but they are equally so to all fluids which are susceptible to fermentation and putrefaction. The effects produced by bacteria are so serious, and the action of these organisms is so insidious, that it is alarming to be told that chemical analysis is powerless to detect their presence. As bacteria are known to flourish and propagate in certain nutritive media, we can by a chemical examination of a water ascertain its probable power of developing these organisms, and therefore chemical analysis is after all a valuable guide in the selection of a sample of water, whether it be required for drinking, brewing, malting, or other industrial purposes.

Practically, few positions offer more favourable conditions for the rapid development of fungoid organisms than steeping-cisterns and growing-floors. The conditions of light, air-supply, moisture, heat, and pabulum or soil, are all and severally almost precisely those that would be adopted if a maltster's aim were the propagation of mould; consequently, few other industries are capable of deriving such direct benefit from a proper conception of what mould is, its causes and cures.

6. IMPURITY OF WATER USED FOR STEEPING AND SPRINKLING.

With the almost universal tendency to attend to minor matters and neglect the major, the water-supply is generally the last thing thought of—if it be considered at all—in the selection of the site of a malting. Generally, the building is erected, and the inquiry as to possible source of water left till the last. Consequently, in many cases, very bad water is used. Where it is drawn from a covered well, or still better, a bore-hole lined with tubes, it is not likely to contain spores or germs of mould or bacteria, unless there is direct connection between the well and some source of organic impurity. But surface water, no matter how free it may be from putrefying matter, as shown by the tests now in vogue among analysts, may yet, and in ninety-nine cases out of a hundred *does*, contain many vital germs and spores, which require only a conjunction of suitable nourishment and congenial temperature to develope their destructive powers.

Even if water contains no such germs, the salts (nitrates, phosphates, &c.), which may have been derived from organic contamination, favour the development of mould and like organisms, of which a sufficient stock is invariably adherent to the grain itself. It has been claimed for such waters that these salts foster the growth of the embryo, but in the first place the germ of every grain contains just the saline nutriment that the embryo requires, without the adventitious aid of dirty water;

in the second place, by the use of such water we foster detrimental life to a much greater extent than that of the barley; and thirdly, such water rarely fails to take *from* the grain some of the salts essential to its growth. (See Chap. V.)

VARIETIES OF MOULD.

Unlike higher plants, moulds, and fungi in general, have no power of assimilating inorganic matter, but exist on the decomposition of previous organisms, either whilst still living, as mildew, rust, smut, &c., or after death, as mould, yeast, &c. They not only thrive upon matter spontaneously produced by the object of their parasitism, but by carrying into it atmospheric oxygen in their mycelial tubes, promote the decomposition by which they benefit. Some have a two-fold system of reproduction, sexual and non-sexual, alternating generations being produced by each; the spores produced by a union of two individuals developing mycelia, which throw off, independently, non-sexual spores, of which the mycelia again conjugate, and so on.

Some of those forms that are parasitic on the living plant oscillate between widely diverse vegetable species, and vary greatly in appearance in their alternate generations. Thus the wheat-rust and barberry-rust are recognised as the same species, living alternately on the barberry and on wheat, and presenting wholly different appearances in each case.

Mildew.

Mildew in barley is favoured, in the opinion of Mr. Mechi,* by too thick sowing and consequent early laid crops. " The " densely packed mass of plants, weak below, tumbles down " flat, or twisted in various directions by winds and thunder " storms, and thatches the earth, so that while rain can pass " through the thatch, the wet earth is shaded from the action " of the sun and air, and becomes in the like condition to a " damp and dark cellar, where mildew and fungi flourish. " When crops stand erect, there is free circulation of air and " access of light, and free evaporation of moisture from the " earth. Drainage also influences this, and so does the absence " of trees and fences."

Brefeld† has very fully described the large variety of moulds, etc. Those occurring in grain, malt, etc., are:—

Mucor mucedo.
M. racemosus.
M. stolonifer.
Eurotium aspergillus.
Penicillium glaucum.

The first and last of these are the maltster's greatest enemies, their development tending to suppress the others. As their presence in the state of spores is scarcely perceptible with a less magnifying power than 300 linear, and their mycelia are quite visible after a few hours' development, it is unnecessary here to describe their microscopic appearances, especially as all are alike objectionable.

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* J. J. MECHI, Profitable Farming, p. 339.

† Untersuchungen über Schimmelpilze.

PREVENTION OF MOULD.

I have already mentioned various precautions to be taken against mould, viz., rejection of visibly mouldy, mixed, and damaged barley; thorough screening, brushing, and washing of grain; cleansing (and *keeping clean*) cisterns and all other parts of the malting; frequent or continuous change of steep-liquor; attention to nature of water used for steeping and sprinkling, and of air admitted to the building, and the use, when necessary, of antiseptic substances. In respect of the last point I may add that some have advocated the use of hydrochloric-acid gas, evolved by heating a mixture of salt and sulphuric acid. The hydrochloric vapour is not so efficacious as chlorine or sulphurous acid, but is less irrespirable, and is more rapidly absorbed by moist surfaces or water.

Chlorine is readily evolved from a mixture of hydrochloric acid and binoxide of manganese (spirits of salt and black manganese), and sulphurous acid is formed by simply burning sulphur.

Strict attention should be given to the ventilation of the growing-floors. Any accumulation of the carbonic acid gas evolved from the grain induces stagnation in growth by exclusion of oxygen, and at the same time implies rise of temperature, increasing evaporation, and other conditions favouring mould-development.

The turning of the floors should be thoroughly executed, as it not only tends to destroy the mould by breaking the mycelia, but the disturbance sweeps away those that may be commencing operations on the exterior of sound grain. The evil of irregularities and cracks in the floors has been already referred to, and the action of heat, light, and air has been dealt with by me in numerous places throughout this book.

The high temperature of the kiln, whilst destroying all mould that is in course of development, has probably little effect on ripe spores, unless applied while the malt is still moist. Such treatment, however, produces still greater evils than mould. If the drying be thorough, many of the spores are removed in screening, and such as remain cannot develope unless the storage is defective and damp, and the percentage of the moisture left in the malt is sufficiently large to foster fungoid growth. It is difficult to determine the precise percentage that suffices, but, so far as our knowledge yet extends, it is fair to assume it to be at or about 4 per cent.

In writing the last page of this book, the sense of relief at the completion of so heavy a task is modified by the fear that the true spirit that has impelled me forward during the many,

many, weary hours it has caused me, will not be appreciated or understood. I have aimed to benefit the craft of malt-making, and to improve the character of malt. I trust that all maltsters may gather something of use or value here and there from its pages, and I hope the plainness of speech indicating detestation of all that is mean, false, ignorant, and dirty, will in no case be applied individually, but be accepted in a wide general sense.

PART V.—LITERATURE AND STATISTICS.

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BIBLIOGRAPHY.

THE following list of works (books and papers) has, necessarily, somewhat arbitrary limits. To have included all the literature of hops, sugar, alcohol, distillation, cultivation of beet-root, &c., would have greatly exceeded the space at disposal. On the other hand, as many brewers may refer to it, numerous titles have been entered that refer to details of brewing, though possibly dealing not at all, or but very slightly, with malt.

Of anonymous matter, only the more important works have been entered at the end of the list. Numerous valuable papers are necessarily omitted.

The contractions used are, in many cases, self-intelligible, but a complete list, with full titles of the journals, is given at the end of the chapter.

Titles in square brackets are given in cases where only the English of the title is mentioned in the source from which the entry is obtained, or where the original publication has no title.

It has been impossible to refer to many authors to verify and authenticate the entries appearing under their names. As a consequence, I shall be very grateful to anyone who may inform me of the inaccuracies that may be noted.

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2298. ——— Anleitung zum Gebrauche des Sacharometers bei der Erzeugung und Prüfung des Bierwürzen. . . . 8vo. *Prague,* 1855.

2299. ——— Anleitung zur Vornahme der sacharometrischen Bierprobe. 8vo. *Prague,* 1855.

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LIST OF CONTRACTIONS.

[*Where not otherwise stated the works are in octavo form.*]

Abh. k. preuss. Ak. Wiss.—Abhandlungen der königlich-preussischen Akademie der Wissenschaften zu Berlin. 4to. *Berlin.*

Abh. Nat. Ges. Görlitz.—Abhandlungen der naturforschenden Gesellschaft zu Görlitz. *Görlitz.*

Abh. Schles. Ges.—Abhandlungen der Schlesischen Gesellschaft für vaterländische Cultur. Abtheilung für Naturwissenschaften und Medicin. *Breslau.*

Act. Soc. Sci. Fenn.—Acta Societatis Scientiarum Fennicæ. *Helsingfors.*

Act. Soc. Linn. Bordeaux.—Actes de la Société Linnéenne de Bordeaux. *Bordeaux.*

Aeronaute.—L'Aéronaute : Bulletin Mensuel International de la Navigation Aérienne. *Paris.*

Allg. Brau.- Hopf.- Zeit.—Allgemeine Brauer - und Hopfen - Zeitung. *Nüremberg.*

Allg. Hopfenzeit.—Allgemeine Hopfenzeitung.

Allg. Journ. Chem.—Allgemeines Journal der Chemie. *Leipzig.*

Allg. Zeitschr. Bierbr. Malzf.—Allgemeine Zeitschrift für Bierbrauerei und Malzfabrikation. *Vienna.*

Amer. Bierbr.—Der Amerikanische Bierbrauer.

Amer. Brewers' Journal.—The German and American Brewers' Journal and Barley, Malt, and Hop-Trades' Reporter. Fo. *New York.*

Amer. Journ.—The American Journal of Science and Arts. *Newhaven, U.S.*

Analyst.—The Analyst, including the Proceedings of the Society of Public Analysts ; a monthly Journal of Analytical Chemistry. *London.*

Ann. Agric. Aisne.—Annales Agricoles de l'Aisne, publiées par la Société des Sciences, Belles-Lettres et Arts de St. Quentin. *St. Quentin.*

Ann. Agron.—Annales Agronomiques. *Paris.*

Ann. Bot.—Annals of Botany. *London.*

Ann. Chim.—Annales de Chimie. *Paris.*

Ann. Chim. (Ital.)—Annali di Chimica. *Milan.*

Ann. Chim. Phys.—Annales de Chimie et de Physique. *Paris.*

Ann. Fis. Chim.—Annali di Fisica, Chimica e Matematica ; col Bulletino dell' Industria Meccanica e Chimica. *Turin* and *Milan.*

Ann. Génie. Civil.—Annales du Génie Civil. Recueil de Mémoires sur les Mathématiques pures et appliquées, l'Astronomie, la Chimie, la Physique, &c. *Paris.*

Ann. Hygiène. Publ.—Annales d'Hygiène Publique. *Paris.*

Ann. Chem. Pharm.—Annalen der Chemie und Pharmacie. *Leipzig* and *Heidelberg.*

Ann. Landw.—Annalen der Landwirthschaft in den k. Preussischen Staaten. *Berlin.*

Ann. Mines.—Annales des Mines, ou Recueil des Mémoires sur l'Exploitation des Mines et sur les Sciences et les Arts qui s'y rapportent. *Paris.*

Ann. Mus. Hist. Nat. Paris.—Annales du Muséum d'Histoire Naturelle à Paris. 4to. *Paris.*

Ann. Nat. Hist.—Annals of Natural History; or, Magazine of Zoology, Botany, and Geology. *London.*

Ann. Phil.—Annals of Philosophy; or, Magazine of Chemistry, Mineralogy, Mechanics, Natural History, Agriculture, and the Arts. *London.*

Ann. Rep. Agric. Ohio.—Annual Reports of the Board of Agriculture of the State of Ohio. *Columbus.*

Ann. Phys.—Annalen der Physik. *Halle.*

Ann. Phys. Chem.—Annalen der Physik und Chemie. *Leipsig.*

Ann. Sci. Ecole. Norm. Paris.—Annales Scientifiques de l'Ecole Normale Supérieure. 4to. *Paris.*

Ann. Sci. Nat.—Annales des Sciences Naturelles. *Paris.*

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Ann. Soc. Entom. France.—Annales de la Société Entomologique de la France. *Paris.*

Ann. Soc. Linn. Lyon.—Annales de la Société Linnéenne de Lyon. *Lyons.*

Ann. Soc. Linn. Maine et Loire.—Annales de la Société Linnéenne du Département de Maine-et-Loire. *Angers.*

Ann. Univ. Med.—Annale Universali di Medicina. *Milan.*

Ann. Wett. Ges. Nat.—Annalen der Wetterauische Gesellschaft für die gesammte Naturkunde. *Hanau.*

Arch. Agric. Chem. Landw.—Archiv der Agriculturchemie fur denkende Landwirthe. *Berlin.*

Arch. Anat. Physiol. Med.—Archiv für Anatomie, Physiologie, und Wissenschaftliche Medicin, etc. *Berlin.*

Archiv. Chem. Meteor.—Archiv für Chemie und Meteorologie. *Nüremberg.*

Arch. gesammt. Naturl.—Archiv für die gesammte Naturlehre. *Nüremberg.*

Arch. gesammt. Physiol.—Archiv für die gesammte Physiologie des Menschen und der Thiere. *Bonn.*

Arch. Holl. Beitr. Natur. Heilk.—Archiv für die Holländischen Beiträge zur Natur. und Heilkunde. *Utrecht.*

Arch. Klin. Med.—Deutsches Archiv für Klinische Medecin. *Leipsig.*

Arch. Path. Anat. Physiol.—Archiv für Pathologische Anatomie und Physiologie und für Klinische Medicin. *Berlin.*

Arch. Pharm.—Archiv für die Pharmacie und ärztliche Naturkunde. *Cassel.*

Arch. Physiol.—Archiv für die Physiologie. *Halle.*

Arch. Sci. Phys. Nat.—Bibliothèque Universelle et Revue Suisse.—Archives des Sciences Physiques et Naturelles. *Geneva.*

Arch. wiss. Heilk.—Archiv des Vereins für gemeinschaftliche Arbeiten zur Förderung der wissenschaftlichen Heilkunde. *Gottingen.*

Atti R. Acc. Linc.—Atti della Reale Accademia dei Lincei. [divided into *Memorie* and *Transunti*]. 4to. *Rome.*

Australian Brewers' Journal.—The Australian Brewers' Journal, Mineral Water, Wine, and Spirit Trade Review. 4to. *Melbourne.*

Bay. Bierbr.—Der Bayerische Bierbrauer. *Munich.*

Belgique Horticole.—La Belgique Horticole. *Brussels.*

Ber. deutsch. chem. Ges.—Berichte der deutschen chemischen Gesellschaft. *Berlin.*

Ber. nat. med. Ver. Innsbruck.—Berichte des naturwissenschaftlich-medicinischen Vereins. *Innsbruck.*

Ber. deutsch. nat. Versamml.—Berichte des deutscher naturforschenden Versammlungen. *Berlin.*

Ber. k. preuss. Ak. Wiss.—Bericht über die Bekanntmachung geeigneten Verhandlungen der königlichen preussischen Akademie der Wissenschaften zu Berlin. *Berlin.*

Ber. Mitth. Freund. Nat. Wien.—Berichte über die Mittheilungen von Freunden der Naturwissenschaften in Wien. *Vienna.*

Ber. Naturf. München.—Bericht der Naturforscher in München. *Munich.*

Bibl. Britann.—Bibliothèque Britannique, ou Recueil extrait des Ouvrages Anglais périodiques et autres: partie des Sciences et Arts. *Geneva.*

Bibl. Farm. Chim.—Biblioteca di Farmacia, Chimica, etc. *Milan.*

Bibl. Ital.—Biblioteca Italiana, ossia Giornale di Letteratura, Scienze, etc. *Milan.*

Bierbr.—Der Bierbrauer. *Munich.*

Bierbr. Bohm.—Der Bierbrauer aus Böhmen. *Prague.*

Bijdr. Nat. Wet.—Bijdragen tot de natuurkundige Wetenschappen. *Amsterdam.*

Böhm. Bierbr.—Der böhmische Bierbrauer. *Prague.*

Bonplandia.—Bonplandia; Zeitschrift für die gesammte Botanik; Organ für Botaniker, Pharmaceuten, Gärtner und Landwirthe. *Hanover.*

Bot. Gazette.—The Botanical Gazette. *London.*

Botan. Unters.—Botanische Untersuchungen des Physiologischen Laboratorium der landwirthschaftlichen Lehranstalt . . . . mit Beiträgen deutscher Physiologen und Anatomen. *Berlin.*

Botan. Wochenbl.—Oesterreichisches Botanisches Wochenblatt. *Vienna.*

Botan. Zeit.—Botanische Zeitung. 4to. *Berlin.*

Brewers' Journal.—The Brewers' Journal and Hop and Malt Trades' Review. 4to. *London.*

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Brewing Trade Gazette.—The Brewing Trade Gazette: a Monthly Journal devoted to the Interests of Brewers, Publicans, Wine and Spirit Merchants, Maltsters, Mineral Water Manufacturers, &c. 4to. *London.*

British Corn-Trade Journal.—The British Corn-Trade Journal. *London.*

Bull. Acad. Ebroic.—Bulletin de l'Académie Ebroicienne de Louviers. *Louviers.*

Bull. Ac. Imp. Sci. St. Petersburg.—Bulletin de l'Académie Impériale des Sciences de St. Petersburg. *St. Petersburg.*

Bull. Ac. Méd. Belg.—Bulletin de l'Académie Royale de Médecine de Belgique à Bruxelles. *Brussels.*

Bull. Ac. Roy. Belg.—Bulletin de l'Académie Royale des Sciences, &c., de Belgique. *Brussels.*

Bull. Inst. Nat. Genèv.—Bulletin de l'Institut National Genèvois. *Geneva.*

Bull. Pharm.—Bulletin de Pharmacie. *Paris.*

Bull. Sci. Math.—Bulletin des Sciences Mathématiques, Astronomiques, Physiques, et Chimiques. *Paris.*

Bull. Sci. Nat.—Bulletin des Sciences Naturelles et de Géologie de la Société pour la Propagation des Connaissances Scientifiques et Industrielles. *Paris.*

Bull. Soc. Bot. France.—Bulletin de la Société Botanique de France. *Paris.*

Bull. Soc. Chim. Paris.—Bulletin de la Société Chimique, un Répertoire de Chimie. *Paris.*

Bull. Soc. Emul. Rouen.—Bulletin de la Société d'Emulation de Rouen. *Rouen.*

Bull. Soc. Encour. Paris.—Bulletin de la Société d'Encouragement de Paris. *Paris.*

Bull. Soc. Géogr. Paris.—Bulletin de la Société de Géographie de Paris. *Paris.*

Bull. Soc. Imp. Nat. Mosc.—Bulletin de la Société Impériale de Naturalistes de Moscou. *Moscow.*

Bull. Soc. Linn. N. France.—Compte-rendu et Bulletin de la Société Linnéenne du Nord de la France. *Abbeville.*

Bull. Soc. Linn. Norm.—Bulletin de la Société Linnéenne de Normandie. *Caen.*

Bull. Soc. Philom. Paris.—Bulletin de la Société Philomatique de Paris. *Paris.*

Bull. Soc. Sci. Agric. Arts Alsace Infér.—Bulletin de la Société des Sciences, Agriculture et Arts de la Basse Alsace (Bas Rhin). *Strasburg.*

Bull. Soc. Sci. Hist. Nat. Yonne.—Bulletin de la Société des Sciences Historiques et Naturelles de l'Yonne. *Auxerre.*

Bull. Soc. Sci. Nat. Neuchâtel.—Bulletin de la Société des Sciences Naturelles de Neuchâtel. *Neuchatel.*

Canad. Nat.—Canadian Naturalist and Quarterly Journal of Science, with the Proceedings of the Natural History Society of Montreal. *Montreal.*

Cas. Spol. Pivov. Cesk.—Casopis Spolku pramysl Pivovarsky v Král Ceskem.

Centr. Agrik.-Chem.—Central-Blatt für Agrikultur-Chemie.

Centr. Land.-Förstw. Böhm.—Centrablatt für Land-und Förstwirthschaft Böhmens.

Chem. Ann. Freund. Nat.—Chemische Annalen für die Freunde der Naturlehre, Arzneygelahrtheit, Haushaltungskunst und Manufacturen. *Helmstadt.*

Chem. Centr.—Chemisches Centralblatt. *Leipzig.*

Chem. Gazette.—The Chemical Gazette, or Journal of Practical Chemistry in all its applications to Pharmacy, Arts, and Manufactures. *London.*

Chem. News.—The Chemical News and Journal of Physical Science. 4to. *London.*

Chemist.—The Chemist, a Monthly Journal of Chemical and Physical Science. *London.* [Secondary title varies.]

Comp. Bot. Mag.—Companion to the Botanical Magazine. *London.*

Compt. Rend.—Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences de l'Institut de France. 4to. *Paris.*

Congr. Sci. France.—Sessions des Congrès Scientifiques de France.

Contemp. Rev.—The Contemporary Review. *London.*

Corr.-Blatt nat. Ver. Riga.—Correspondenz-Blatt des naturforschenden Vereins zu Riga. *Riga.*

Corr.-Blatt zool.-min. Ver. Regensb.—Correspondenz-Blatt des zoologisch-mineralogischen Vereins zu Regensburg. *Ratisbon.*

Cosmos.—Cosmos. Révue Encyclopédique Hebdomadaire des Progrès des Sciences. *Paris.*

Country Brewers' Gazette.—The Country Brewers' Gazette. Hop and Malt Trades' Chronicle. The Official Organ of the Country Brewers' Society. *London.*

Denkschr. k.-bay. Ak. Wiss.—Denkschriften der königlich-baierische Akademie der Wissenschaften. *Munich.*

Edin. N. Phil. Journ.—The Edinburgh New Philosophical Journal, exhibiting a View of the Progress in Natural Philosophy, Chemistry, Natural History, Comparative Anatomy, Practical Mechanics, Geography, Navigation, Statistics, and the Fine and Useful Arts. *Edinburgh.*

Electr. Mag.—The Electrical Magazine. *London.*

Engineer.—The Engineer. fo. *London.*

Entom. Zeit.—Entomologische Zeitung. *Stettin.*

Flora.—Flora oder allgemeine botanische Zeitung; herausgegeben von der koniglich-bayerischen botanischen Gesellschaft. *Ratisbon.*

Gambrinus.—Gambrinus. *Vienna?*

Gazz. Chim. Ital.—Gazzetta Chimica Italiana. *Palermo.*

Gel. anz. k. bay. Ak. wiss.—Gelehrte Anzeigen der kön. bayerische Akademie der Wissenschaften. *Munich.*

Giorn. Arcad. Sci.—Giornale Arcadice di Scienze. *Rome.*

Giorn. Farm.—Giornale di Farmacia, Chimica, e Scienze Accessorie, ossia Raccolta delle Scoperte, retrovate e miglioramente fatte in Farmacia ed in Chimica. *Milan.*

Giorn. Fis. Chim. St. Nat.—Giornale di Fisica, Chimica e Storia Naturale, Medicina ed Arti del Regno Italico. 4to. *Pavia.*

Hedwigia.—Hedwigia; ein Notizblatt für Kryptogamische Studien, nebst Repertorium für Kryptogamische Literatur. *Dresden.*

Hooker's Journ. Bot.—Hooker's Journal of Botany, and Kew Gardens Miscellany. *London.*

Intell. Observer.—The Intellectual Observer: a Review of Natural History, Microscopic Research, and Recreative Science. *London.*

Iron.—Iron: the Journal of Science, Metals, and Manufactures, with which is incorporated the Mechanic's Magazine. fo. *London.*

Isis. Encycl. Zeit.—Isis, oder Encyclopädische Zeitung. 4to. *Jena.*

Jahrb. Bot.—See *Jahrb. wiss. Botan.*

Jahrb. Chem. Phys.—Jahrbuch der Chemie und Physik. *Nuremberg.*

Jahrb. wiss. Botan.—Jahrbuch für wissenschaftliche Botanik. *Berlin.*

Jahresb. k. Centr. Sch. Wiehenstephan.—Jahresbericht der k. Central-Schule zu Wiehenstephan.

Jahresh. nat. Ges. Brunn.—Jahresheft der naturwissenschaftlichen Section der kais.-kön. mahrisch-schlesischen Gesellschaft für Ackerbau, Natur-, und Landeskunde. *Brünn.*

Jahresb. Oesterr. Brauer. Schule.—Jahresberichte der Erste Oesterreichischen Brauer Schule. *Mödling.*

Jen. Zeitschr. Med. Nat.—Jenaische Zeitschrift für Medicin und Naturwissenschaft. *Leipzig.*

Journ. Agric.—The [Quarterly] Journal of Agriculture. *Edinburgh.*

Journ. Agric. Prat.—Journal d'Agriculture Pratique, &c. *Paris.*

Journ. Agric. Soc. India.—Journal of the Agricultural and Horticultural Society of India. *Calcutta.*

Journ. Bath W. Engl. Soc.—Journal of the Bath and West of England Society and Southern Counties Association for the Encouragement of Agriculture, Arts, Manufactures, and Commerce. *Bath.*

Journ. Bot.—Journal of Botany, English and Foreign. *London.*

Journ. Brass.—Journal des Brasseurs. *Brussels.*

Journ. Chem. Phys.—Journal [oder Jahrbuch] der Chemie und der Physik. 8vo. *Nuremberg.*

Journ. Chem. Phys. Min.—Journal für die Chemie und Physik und Mineralogie. *Berlin.*

Journ. Chem. Soc.—Journal of the Chemical Society. *London.*

Journ. Chim. Méd.—Journal de Chimie Médicale, de Pharmacie et de Toxicologie et Revue des Nouvelles scientifiques nationales et étrangères. *Paris.*

Journ. de Bot.—Journal de Botanique; par une Société de Botanistes. *Paris.*

Journ. Hortic. Soc.—The Journal of the Horticultural Society of London. *London.*

Journ. Landw.—Journal für Landwirthschaft.

Journ. Méd.—Journal hebdomadaire de Médecine. *Paris.*

Journ. Méd. Loire Infér.—Journal de la Section de Médecine de la Société Académique du Département de la Loire Inférieure. *Nantes.*

Journ. Nat. Phil. Chem. Arts.—Journal of Natural Philosophy Chemistry and the Arts. 4to. *London.*

Journ. Pharm.—Journal de Pharmacie, et des Sciences Accessories. *Paris.*

Journ. Pharm. Apothek.—Journal der Pharmacie für Aerzte und Apotheker. *Leipzig.*

Journ. Phys.—Journal de Physique de Chimie, d'Historie Naturelle et des Arts. 4to. *Paris.*

Journ. prakt. Chem.—Journal für praktische Chemie. *Leipzig.*

Journal R. Agric. Soc.—Journal of the Royal Agricultural Society of England. *London.*

Journ. R. Dublin Soc.—Journal of the Royal Dublin Society. *Dublin.*

Journ. R. Inst.—Journal of the Royal Institution of Great Britain. *London.*

Journ. R. Microsc. Soc.—Journal of the Royal Microscopical Society, containing its Transactions and Proceedings; with other Microscopical and Biological information. *London.*

Journ. Soc. Arts.—Journal of the Society of Arts. *London.*

Journ. Soc. Chem. Industr.—Journal of the Society of Chemical Industry. *London.*

Journ. techn. Chem.—Journel für technische und ökonomische Chemie. *Leipzig.*

Landw. Centr. Deutsch. — Landwirthschaftliches Centralblatt für Deutschland.

Landw. Jahrb.—Landwirthlicher Jahrbuch.

Landw. Versuchs. Stat.—Die Landwirthschaftlichen Versuchs-Stationen. Organ für wissenschaftliche Forschungen auf dem Gebiete der Landwirthschaft. *Dresden* and *Chemnitz.*

Les Mondes.—Les Mondes, Revue hebdomadaire des Sciences et de leurs applications aux Arts et à l'Industrie. *Paris.*

Linnæa.—Linnæa; ein Journal für die Botanik in ihrem ganzen Umfange. *Berlin.*

L'Institut.—L'Institut, Journal des Academies et Sociétés Scientifiques de la France et de l'Etranger. fo. *Paris.*

Maandbl. Natuurw.—Maandblatt voor Natuurwetenschappen.

Mag. Ges. Nat. Freunde Berlin.—Magazin der Gesellschaft naturforschender Gesellschaft in Berlin für die neuesten Entdeckungen in der gesammten Naturkunde. 4to. *Berlin.*

Mag. Nat. Hist.—The Magazine of Natural History, and Journal of Zoology, Botany, Mineralogy, Geology and Meteorology. *London.*

Mag. Pharm.—Magazin für Pharmacie, Botanik und Materia Medica. *Halle.*

Mag. Zust. Naturk.—Magazin für den neuesten Zustand der Naturkunden, mit Rücksicht auf die dazu gehörigen Hülfswissenschaften. *Jena.*

Mechan. Eng.—Mechanical Engineering. fo. *London.*

Med. Chem. Unters.—Medicinisch-chemischen Untersuchungen.

Medd. Carlsb. Laborat.—Meddelelser fra Carlsbergs Laboratoriet. *Copenhagen.*

Mem. Acc. Agric. Verona.—Memorie dell' Accademia di Agricoltura di Verona. *Verona.*

Mém. Ac. Berlin.—Mémoires de l'Academie Royale des Sciences de Berlin. 4to. *Berlin.*

Mém. Ac. Imp. Sci. St. Petersburg.—Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg. *St. Petersburg.*

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Mém. Ac. Montpellier.—Mémoires de la section des Sciences de l'Académie des Sciences et Lettres de Montpellier. *Montpellier.*

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Mém. Ac. Stanislas.—Academie de Stanislas. Mémoires de la Société des Sciences, &c., de Nancy. *Nancy.*

Mém. Ac. Toulouse.—Mémoires de l'Académie des Sciences, Inscriptions et Belles-Lettres de Toulouse. *Toulouse.*

Mem. Chem. Soc.—Memoirs and Proceedings of the Chemical Society of London. *London.*

Mém. Cour. Ac. Roy. Belg.—Mémoirs couronnés et autres Mémoires publiés par l'Academie Royale des Sciences . . . . de Belgique. 4to. *Brussels.*

Mém. Inst. Paris.—Mémoires de la Classe des Sciences Mathématiques et Physiques de l'Institut. 4to. *Paris.*

Mem. Lit. Phil. Soc. Manch.—Memoirs of the Literary and Philosophical Society of Manchester. *Manchester.*

Mém. Méd. Chir. Pharm.—Mémoires de la Médecine, de la Chirurgie et de la Pharmacie.

Mém. Méd. Milit.—Recueil de Mémoires de Médecine, de Chirurgie, et de Pharmacie Militaires, rédigé sous la Surveillance du Conseil de Santé. *Paris.*

Mém. Mus. Hist. Nat. Paris.—Mémoires du Museum d'Histoire Naturelle. 4to. *Paris.*

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Mem. R. Ist. Lomb.—Memorie del Reale Istituto Lombardo di Scienze e Lettere. *Milan.*

Mem. Sci. Dep. Univ. Tôkiô.—Memoirs of the Science Department of the University of Tôkiô. 4to. *Tokio.*

Mém. Soc. Agric. Aube.—Mémories de la Société d'Agriculture, des Sciences, et des Lettres du Département de l'Aube. *Troyes.*

Mém. Soc. Agric. Douai.—Mémoires de la Société d'Agriculture, de Sciences, et d'Arts séant à Douai. *Douai.*

Mém. Soc. Agric. Mende.—Mémoires et Analyses des Travaux de la Société d'Agriculture, Commerce, Sciences, et Arts de la Ville de Mende, Département de la Lozère. *Mende.*

Mém. Soc. Biol. Paris.—Comptes Rendus des Séances et Mémoires de la Société Biologique. *Paris.*

Mém. Soc. Centr. Agric. France.—Mémoires de la Société Centrale d'Agriculture de France.

Mém. Soc. Emul. Cambrai.—Mémoires de la Société d'Emulation à Cambrai. *Cambrai.*

Mem. Soc. Ital. Sci. Modena.—Memorie di Matematica e di Fisica della Società Italiana delle Scienze residente in Modena. 4to. *Modena.*

Mém. Soc. Linn. Norm.—Mémoires de la Société Linnéenne de Normandie. *Paris.*

Mém. Soc. Phys. Hist. Nat. Genève.—Mémoires de la Société de Physique d'Histoire Naturelle de Genève. *Geneva.*

Mém. Soc. Sci. Agr. Arts. Lille.—Mémoires de la Société des Sciences, de l'Agriculture et des Arts de Lille. *Paris.*

Mém. Soc. Sci. Phys. Nat. Bordeaux.—Mémoires de la Société des Sciences Physiques et Naturelles de Bordeaux. *Bordeaux.*

Mém. Soc. Sci. Nat. Seine-et-Oise.—Mémoires de la Société des Sciences Naturelles de Seine-et-Oise. *Versailles.*

Mém. Soc. Sci. Strasbourg.—Mémoires de la Société des Sciences Naturelles de Strasbourg. 4to. *Strasburg.*

Micr. Journ.—The Monthly Microscopical Journal, Transactions of the Royal Microscopical Society, and record of histological research at home and abroad. *London.*

Micr. Journ. Struct. Rec.—The Microscopical Journal and Structural Record. *London.*

Millers' Gazette.—The Millers' Gazette and Corn Trade Journal. 4to. *London.*

Mitth. k.-k. mahr-schles. Ges. } Mittheilungen der kaiserlich-königlicher
Mitth. Nat. Ges. Brünn. } mährisch-schlesischer Gesellschaft zur Beförderung des Ackerbaues, der Natur- und Landeskunde. 4to. *Brünn.*

Mitth. nat. Ges. Bern.—Mittheilungen der naturforschenden Gesellschaft in Bern. *Berne.*

Monatsb. k.-preuss. Ak. Wiss.—Monatsberichte der königlich-preussischen Akademie der Wissenschaften zu Berlin. *Berlin.*

Monatsh. Chem.—Monatshefte fur Chemie und verwandte Theile änderen Wissenschaften. *Vienna.*

Moniteur Scient.—Le Moniteur Scientifique. *Brussels ?*

Mus. Senckenb.—Musaeum Senckenbergianum. Abhandlunger aus dem Gebiete der Beschreiben den Naturgeschichte. 4to. *Frankfort.*

Mus. Wiss. Nat.—Museum des Neuesten und Wissenwürdigsten aus dem Gebiete der Naturwissenschaft, der Künste, der Fabriken, der Manufakturen, der technischen Gewerbe, der Landwirthschaft, der Produktenwaaren und Handelskunde und den bürgerliche Haushaltung, &c. *Berlin.*

N. allg. Journ. Chem.—Neues allgemeines Journal der Chemie. *Leipsig.*

Nat. Tijdschr. Ned-Ind.—Natuurkundig Tijdschrift voor Nederlandsch Indië uitgegeven door de Natuurkundige Vereeniging . . . . *Batavia.*

Nature.—Nature, a Weekly Illustrated Journal of Science. 4to. *London.*

N. Comment. Bologna.—Novi Commentarii Academiæ Scientiarum Instituti Bononiensis. 4to. *Bologna.*

Nederlandsch. Lancet.—Nederlandsch Lancet. Tijdschrift aan de praktische Chirurgie, &c. *Utrecht.*

New England Journ. Med.—New England Journal of Medicine and Surgery. *Boston.*

N. Journ. Chem. Phys.—Neues Journal für Chemie und Physik. *Nuremberg.*

N. Journ. Pharm.—Neues Journal der Pharmacie fur Aerzte Apotheker und Chemiker. *Leipsig.*

N. Mem. Soc. Sci. Strasbourg.—Nouveaux Mémoires de la Société des Sciences de Strasbourg. *Strasburg.*

Notiz. Nat. Heilk.—Notizen aus den Gebiete der matur-und Heilkunde. 4to. *Erfurt* and *Weimar.*

Nouv. Ann. Mus. Hist. Nat. Paris.—Nouvelles Annales du Muséum d'Histoire Naturelle. 4to. *Paris.*

Nova. Acta. Ac. Cæs. Leop. Car.—Nova acta Physico-Medica Academiæ Cæsareæ Leopoldino-Carolinæ Germanicæ Naturæ-Curiosorum. 4to. *Ellangen, Bonn, Breslau* and *Dresden.*

N. Rep. Pharm.—Neues Repertorium für die Pharmacie. *Nuremberg.*

N. Schr. k. k. patr.-ökon. Ges.—Neue Schriften der k.-k. patriotisch-ökonomischen Gesellschaft im Königreiche Böhmen. *Prague.*

Öfv. Finska. Vet.-Soc. Förh.—Öfversigt af Finska Vetenskaps-Societeten Förhandlingar. *Helsingfors.*

Öfv. k. Svenska. Vet.-Akad. Förhandl.—Öfversigt af Kongl. Svenska Vetenskaps-Akademiens Förhandlingar. *Stockholm.*

Oesterr. landw. Wochenbl. — Oesterreichisches landwirthschaftliches Wochenblatt.

Oesterr.-ungar. Brau.-Zeit.—Oesterreichs-ungarische Brauerei-Zeitung. *Prague.*

Oesterr-ungar.Brenn.-Zeit.—Oesterreichs-ungarische Brennerei-Zeitung. *Prague.*

Overs. K. Dansk. Vid.-Selsk.—Oversigt over det Kongliche Danske. Videnskabernes-Selskabs. Förhandlinger og dets Medlemmers Arbeider, &c. *Copenhagen.*

Papers Bath Soc.—Letters and Papers on Agriculture, Planting, &c., selected from the Correspondence Book of the Society instituted at Bath for the Encouragement of Agriculture, Arts, Manufactures, and Commerce within the Counties of Somersetshire, Wiltshire, Gloucestershire and Dorsetshire and the city and county of Bristol. *Bath.*

Pharm. Centr.—Pharmaceutisches Central-Blatt. *Leipzig.*

Pharm. Journ.—Pharmaceutical Journals and Transactions. *London.*

Pharm. Zeitschr. Russl.—Pharmaceutische Zeitschrift für Russland. Namens der allerhöchst bestatigen pharmaceutischen Gesellschaft in St. Petersburg. *St. Petersburg.*

Phil. Mag.—London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science. *London.*

Phytologist.—The Phytologist; a Popular Botanical Miscellany. *London.*

Polyt. Journ.—Polytechnisches Journal. *Stuttgart.*

Polyt. Notizbl.—Polytechnisches Notizblatt. *Mayence.*

Pop. Sci. Rev.—Popular Science Review. *London.*

Prize Essays Pract. Br.—Prize Essays on Practical Brewing. *London.*

Proc. Ac. Nat. Sci. Philadel.—Proceedings of the Academy of Natural Sciences of Philadelphia. *Philadelphia.*

Proc. Amer. Assoc.—Proceedings of the American Association for the Advancement of Science. *Salem.*

Proc. Brit. Pharm. Conference.—Proceedings of the British Pharmaceutical Conference. *London.*

Proc. Chem. Soc.—Proceedings of the Chemical Society, London. *London.*

Proc. Inst. Civ. Eng.—Minutes of Proceedings of the Institution of Civil Engineers. *London.*

Proc. Linn. Soc.—Proceedings of the Linnean Society, London. *London.*

Proc. Phil. Soc. Glasgow.—Proceedings of the Philosophical Society, Glasgow. *Glasgow.*

Proc. R. Irish Acad.—Proceedings of the Royal Irish Academy. *Dublin.*

Proc. Roy. Soc.—Proceedings of the Royal Society of London. *London.*

Proc. Verb. Soc. Philom. Paris.—Extraits des Procès-verbaux des Séances de la Société Philomatique de Paris. *Paris.*

Quart. Journ. Micr. Sci.—Quarterly Journal of Microscopical Science. *London.*

Quart. Journ. Sci.—Quarterly Journal of Science, and Annals of Mining, Metallurgy, Engineering, Industrial Arts, and Manufactures. *London.*

Rec. Gen. Sci.—Records of General Science. *London.*

Rec. Soc. Agric. Eure.—Recueil de la Société libre d' Agriculture, des Sciences, et des Arts (et Belles-Lettres) du Département de l'Eure. *Evreux.*

Ref. Circ.—Reference Circulars for Brewers, Maltsters and Distillers. *London.*

Rend. R. Ac. Sci. fis. Napoli.—Rendiconti della Reale Accademia delle Scienze fisiche a matematiche di Napoli. 4to. *Naples.*

Rend. R. Ist. Lomb.—Rendiconti delle Adunanze del Reale Instituto Lombardo di Scienze e Lettere. *Milan.*

Rep. Brit. Assoc.—Report of the British Association for the Advancement of Science. *London.*

Repert. Pharm.—Repertorium für die Pharmacie. 12mo. *Nuremberg.*

Rev. Cours. Sci.—Revue des Cours Scientifiques de la France et de l'Etranger. 4to. *Paris.*

Rev. Mag. Zool.—Revue et Magasin de Zoologie. *Paris.*

Rev. Univ. Brass. Malt.—Revue Universelle de la Brasserie et de la Malterie. *Paris* and *Brussels.*

Scheik. Verhand.—Scheikundige verhandelingen en onderzoekingen. *Rotterdam.*

Schr. Ver. Nat. Kenntn. Wien.—Schriften des Vereines zur Verbreitung Naturwissenschaftlicher Kenntnisse in Wien. *Vienna.*

Sitz. Isis. Dresden. — Sitzungs-Berichte der naturwissenschaftlichen Gesellschaft Isis in Dresden. *Dresden.*

Sitz. k. ak. Wiss. Wien.—Sitzungsberichte der mathematisch-naturwissenschaftlichen classe der Kaiserlichen Akademie der Wissenchaften der Wien. *Vienna.*

Sitz. k.-böhm. Ges. Wiss.—Sitzungsberichte der königlichen-böhmischen Gesellschaft der Wissenschaften. *Prague.*

Sitz. nat. Ges. Halle.—Sitzungsberichte der naturforschenden Gesellschaft zu Halle. 4to. *Halle.*

Sitz. Ver. Beförd. Gewerbefl.—Sitzungsberichte des Vereins für Beförderung des Gewerbefleiss. *Berlin ?*

Trans. Adelaide Phil. Soc.—Annual Report and Transactions of the Adelaide Philosophical Society. 4to. *Adelaide.*

Trans. Agric. Soc. N. York.—Transactions of the Society instituted in the State of New York for the Promotion of Agriculture, Arts, and Manufactures. *New York.*

Trans. Amer. Chem. Soc.—Transactions of the American Chemical Society. *New York.*

Trans. Amer. Inst.—Transactions of the American Institute. *Boston.*

Trans. Amer. Phil. Soc.—Transactions of the American Philosophical Society, held at Philadelphia, for Promoting Useful Knowledge. 4to. *Philadelphia.*

Trans. Bot. Soc. Edinb.—Transactions and Proceedings of the Botanical Society of Edinburgh. *Edinburgh.*

Trans. Devon. Assoc.—Transactions of the Devonshire Association for the Advancement of Science, Literature, and Art. *Plymouth.*

Trans. Highland Soc.—Prize Essays and Transactions of the Highland Society of Scotland. *Edinburgh.*

Trans. Hortic. Soc.—Transactions of the Horticultural Society of London. 4to. *London.*

Trans. Linn. Soc.—Transactions of the Linnean Society. 4to. *London.*

Trans. N. York Agric. Soc., see *Trans. Agric. Soc. N. York.*

Trans. N. York Med. Soc.—Transactions of the Medical Society of the State of New York. *Albany.*

Trans. R. Cornw. Pol. Soc.—Annual Reports (and Transactions) of the Royal Cornwall Polytechnic Society. *Falmouth.*

Trans. R. Micr. Soc.—Transactions of the Royal Microscopical Society. *London.*

Trans. R. Soc. Edinb.—Transactions of the Royal Society of Edinburgh. 4to. *Edinburgh.*

Trans. Soc. Eng.—Transactions of the Society of Engineers. *London.*

Trans. Tyneside Nat. Club.—Transactions of the Tyneside Naturalists' Field Club. *Newcastle.*

Trav. Ac. Sci. Caen.—Rapport Général sur les Travaux de l'Académie Impériale Naturelle des Sciences, Arts, et Belles-Lettres de Caen. *Caen.*

Uebers. Schles. Ges.—Uebersicht der Arbeiten und Veränderungen der Schlesischen Gesellschaft für vaterländische Cultur. *Breslau.*

Univ. Coll. Lect.—University College Lectures. *London.*

Verh. bot. Ver. Brandenburg.—Verhandlungen des Botanischen Vereins für die Provinz Brandenburg und die angrenzenden Länder. *Berlin.*

Verh. k.-k. zool.-bot. Ver. Wien.—Verhandlungen des Kaiserlich-Königlicher zoologisch-botanischer Vereins zu Wien. *Vienna.*

Verh. Nat. Ges. Basel.—Verhandlungen der Schweizerischen naturforschenden Gesellschaft bei ihrer Versammlung zu Basel. *Basle.*

Verh. nat. Ver. preuss. Rheinl. Westph.—Verhandlungen des naturhistorischen Vereins des preussischen Rheinlande und Westphalens [including *Sitzungsberichte* and *Correspondenz-Blatt*]. *Bonn.*

Verh. phys.-med. Ges. Würzburg.—Verhandlungen der physikalisch-medicinischen Gesellschaft in Würzburg. *Wurtemberg.*

Vierteljahresschr. techn. Chem.—Vierteljahresschrift für technische Chemie, landwirthschaftliche Gewerbe, Fabrikwesen und Gewerbetreibende überhaupt. *Quedlinburg.*

Vierteljahrsschr. Med.—Vierteljahrsschrift für gerichtliche und öffentliche Medicin. *Berlin.*

Western Brewer.—The Western Brewer (Der Westliche Brauer) and Journal of the Barley, Malt, and Hop Trades. *Chicago and New York.*

Wochenschr. Bierbr.—Wochenschrift für Bierbrauerei.

Zeitschr. Akklim.—Zeitschrift für Akklimatisation. *Berlin.*

Zeitschr. allg. Erdk.—Zeitschrift für allgemeine Erdkunde der Gesellschaft für Erdkunde. *Berlin.*

Zeitschr. anal. Chem.—Zeitschrift für analytische Chemie. *Wiesbaden.*

Zeitschr. Brauind. Ver. Kon. Böhm.—Zeitschrift des Brauindustrie-Vereins im Königreich Böhmen. 4to. *Prague.*

Zeitschr. gesammt. Brauw.—Zeitschrift für das gesammte Brauwesen. *Munich.*

Zeitschr. gesammt. Nat.—Zeitschrift für die gesammten Naturwissenschaften. Originalabhandlungen und monatliches Repertorium der. Literatur der Astronomie, Meteorologie, Physik, Chemie, Geologie, Oryktognosie, Palæontologie, Botanik und Zoologie. *Berlin.*

Zeitschr. Parasit.—Zeitschrift für Parasitenkunde. *Halle.*

Zeitschr. physiol. Chem.—Zeitschrift für die physiologische Chemie.

Zeitschr. Spiritus-ind.—Zeitschrift für Spiritus-industrie. *Berlin.*

Zeitschr. Ver. deutsch. Spiritusfabr.—Zeitschrift des Vereins deutscher Spiritusfabrikanten.

Ziva.—Ziva; Casopis przírodnicky. *Prague.*

LIST OF PATENTS.

The titles of the following List of Patents referring to Malting and Brewing have, for economy of space, been reduced to the narrowest limits consistent with definition of the subjects. Up to October 1852, the numbers of Patents were consecutive. From the coming into operation of the Patent Law Amendment Act, 1852, numbering is recommenced each year.

1634.	No.	71B.	Page, N.	Malt-kiln.
,,	,,	75.	Prusen, H., & H. Strachy	Malt-kiln.
1635.	,,	78.	Ramsay, D., M. Arnold, and G. Ayliffe	Bottling.
,,	,,	85.	Halse, Sir N.	Malt-kiln.
1636.	,,	90.	Brouncker, Sir W.	Brewing.
,,	,,	93.	Lindsey, R., & J. Hobart	Coppers.
,,	,,	98.	Peyton, T., W. Williams, W. Browning, and J. Jones	Coking Coal.
1637.	,,	102.	Berks, Thomas, Earle of	Malt-kilns.
1660.	,,	129.	Frank, T.	Coppers.
1698.	,,	358.	Groves, J., and T. Reeve	Malt-kiln.
1699.	,,	361.	Shallcrosse, J.	Kiln-tiles.
1711.	,,	387.	Nasmith, J.	Fermentation.
1713.	,,	394.	Bird, M.	Malt-kiln.
1720.	,,	429.	Busby, J.	Malt-kiln.
,,	,,	430.	Desaguliers, J. T., D. Niblet, and W. Vreem	Steam-boiling.
1723.	,,	455.	Sheldon, R.	Compressing Hops.
1724.	,,	462.	Hines, H.	Coppers.
1728.	,,	505.	Payne, J.	Furnaces.
1729.	,,	513.	Allen, J.	Malt-kiln.
1736.	,,	555.	Payne, J.	Brewing-pans.
1743.	,,	594.	Southgate, J.	Metal growing-floors.
1745.	,,	612.	Kay, J., and J. Stell	Malt-kiln.
1748.	,,	629.	Pickering, R.	Distillation of Pulse with Oatmalt, &c.
1753.	,,	675.	Wilkinson, I.	Malt-rolls.
1760.	,,	749.	Jackson, H.	British Isinglass.
1768.	,,	896.	Meikle, A., & R. Mackell	Malt-screen.
1769.	,,	918.	Willday, S.	Malt-kiln.
1773.	,,	1,056.	Chrysel, C.	Brewing-pans.
1774.	,,	1,090.	Watson, S.	Malt-mill.
1778.	,,	1,190.	Thornton, R.	Concentrated Wort.
1779.	,,	1,214.	Dearman, R.	Malt-rolls.
,,	,,	1,225.	Narbell, I.	Boiler-coating.

1780.	No.	1,259.	Dicas, J.	Hydrometer.
1783.	„	1,395.	Clarke, R.	Malt-kiln.
1784.	„	1,455.	Wood, S. T.	Steam-boiler.
1785.	„	1,477.	Phillips, J.	Furnace.
1786.	„	1,567.	Taylor, W.	Malt-mill.
1787.	„	1,590.	Reinecke, J.	Boiler.
„	„	1,611.	Walker, J.	Mashing-rake.
1788.	„	1,641.	Ker, W.	Condensing Copper Steam.
1789.	„	1,685.	Howson, M.	Fuel-economy.
1790.	„	1,754.	Long, J.	Mashing-system.
„	„	1,769.	Harris, T., and J. Long	Refrigerator.
1791.	„	1,826.	Hare, R.	Condensing Copper Steam.
1792.	„	1,877.	Whitmore, W.	Mashing-rake.
1793.	„	1,965.	Biley, E.	Mashing-rake.
1794.	„	1,995.	Tate, J.	Copper-flues.
1796.	„	2,091.	Matthew, F.	Yeast-press.
„	„	2,116.	Pepper, J.	Malt-kiln.
„	„	2,136.	Cooper, J.	Mashing-rake.
„	„	2,152.	Lloyd, F.	Malt-kiln.
1797.	„	2,162.	Grover, J.	Copper-flue.
„	„	2,170.	Silvester, J.	Mashing-rake.
„	„	2,171.	Goodwin, H., jun.	Mash-tun.
„	„	2,196.	Bramah, J.	Storing, Fining, and Racking.
1798.	„	2,212.	Shannon, R.	Brewing-plant.
„	„	2,236.	Jones, W.	Mashing-rake.
„	„	2,245.	Shannon, R.	Fermenting-tun.
1799.	„	2,336.	Hunt, W., and W. Cliffe	Malt-mill.
1800.	„	2,413.	Tickell, H.	Steam-boiling.
1801.	„	2,495.	Tickell, H.	Cooling.
1802.	„	2,625.	Wood, M.	Colouring from Malt.
„	„	2,640.	Speer, W.	Hydrometers.
1803.	„	2,715.	Storck, P.	Yeast.
„	„	2,726.	Woolf, A.	Steam-boiling.
„	„	2,734.	Gould, C.	Hydrometer.
„	„	2,737.	Atkins, R.	Hydrometers.
„	„	2,740.	Younger, R.	Mash-tun.
„	„	2,746.	Cross, R., and T. Southworth	Boiling-vessels.
1804.	„	2,753.	Pasmore, T.	Malt-mill.
„	„	2,773.	Bentley, T.	Purifying and Seasoning Casks.
1805.	„	2,816.	Barrett, J.	Malt-kilns.
1807.	„	3,017.	Atlee, J. F.	Fermenting-tuns.
„	„	3,036.	Matterface, A.	Mashing-gear.
„	„	3,072.	Day, J.	Brewing Dantzic Spruce.
„	„	3,093.	Salter, S.	Malt-kiln-furnace.
1809.	„	3,263.	De Roche, R. T.	Roasting Malt-husks.
1810.	„	3,315.	Robinson, T.	Mashing-gear.
„	„	3,318.	Shannon, M.	Mash-tun.
„	„	3,320.	Gregory, J.	Cleansing and Racking.
„	„	3,368.	Williams, C.	Malt-mill.
1811.	„	3,493.	Needham, J.	Portable Brewing Plant.
„	„	3,509.	Adam, J.	Drying Malt.
1812.	„	3,546.	Mathew, F.	Pressed-yeast.
„	„	3,575.	Needham, J.	Portable Brewing Plant.
1813.	„	3,651.	Roberts, J.	Concentration of Wort.
„	„	3,669.	King, W. R. W.	Flues for Brewing-coppers, &c.
1814.	„	3,778.	Vallance, J., jun.	Refrigerator.

1814.	No. 3,796.	Smart, G.	Crushing Malt.
,,	,, 3,867.	Vallance, J., jun.	Vats and Store Casks.
1815.	,, 3,916.	Kenrick, A.	Malt-mill.
,,	,, 3,920.	Kilby, J.	Boiling-vessel.
1816.	,, 4,032.	Taylor, P.	Boiling-vessel.
1817.	,, 4,112.	Wheeler, D.	Malt-roasting.
,,	,, 4,133.	Whittle, T., & G. Eyton	Drying Malt.
,,	,, 4,175.	Shears, D. T.	Refrigerator.
1818.	,, 4,197.	Taylor, P.	Steam-boiling and Refrigerating.
,,	,, 4,254.	Bush, W. jun.	Malt Drying.
1819.	,, 4,331.	Salmon, R. & W. Warrell	Cooling.
,,	,, 4,377.	Geldart, W., J. Servant, and J. Howgate	Malt-kilns.
1820.	,, 4,480.	Vallance, J.	Packing Hops.
,,	,, 4,506.	Lobeck, H. L.	Making Yeast.
1821.	,, 4,615.	Arnott, N.	Boiling and Cooling.
1822.	,, 4,659.	Bate, R. B.	Hydrometers and Saccharometers.
,,	,, 4,744.	Richards, G.	Brewery Fires, Flues, &c.
1823.	,, 4,746.	Neville, J.	Boiling, Malting, &c.
,,	,, 4,858.	Bundy, W.	Refrigerator.
1824.	,, 4,997.	Johnson, W.	Steam-boiling.
1825.	,, 5,091.	Lamb, G. A.	Concentrated Wort.
1826.	,, 5,323.	Lorent, A. R.	Steam-boiling.
,,	,, 5,368.	Dembroucq, D. P.	Refrigerator.
,,	,, 5,406.	Yandall, J.	Refrigerator.
1827.	,, 5,565.	Wheeler, R.	Refrigerator.
1829.	,, 5,816.	Salmon, T.	Malt-kiln.
1830.	,, 5,924.	Aitkin, W.	Preservation of Beer, &c.
,,	,, 5,959.	Riley, E.	Rousing Gear.
,,	,, 5,974.	Coffey, Æ.	Refrigerating.
1831.	,, 6,160.	Neville, J.	Filtering Malt-liquors.
1832.	,, 6,266.	Goodlet, G.	Steam-drying.
,,	,, 6,316.	Swan, J.	Hop-press and Yeast-press
1833.	,, 6,468.	Else, R.	Malt-drying.
1834.	,, 6,539.	Bates, J.	Refrigerating.
,,	,, 6,623.	Keele, E.	Valves in Fermenting tuns, and scrapers for cleansing casks.
,,	,, 6,653.	Chanter, J., & W. Witty	Refrigerator.
,,	,, 6,673.	Sheridan, J. J. C.	Fermentation.
1835.	,, 6,783.	Sheridan, J. J. C.	Fermentation.
,,	,, 6,912.	Dyer, J.	Clarification.
,,	,, 6,932.	Sheridan, J. J. C.	Fermentation.
1836.	,, 7,035.	Bate, R. B.	Hydrometers and Saccharometers.
,,	,, 7,157.	Brandt, C.	Endless-web Coolers.
,,	,, 7,181.	Farina, C.	Mashing Gear.
,,	,, 7,211.	Sheridan, J. J. C.	Airtight Fermentation.
,,	,, 7,245.	Don, T.	Quickening Malting by Steam.
1837.	,, 7,328.	Poole, M.	Clarification by Filtering.
,,	,, 7,347.	Farina, C.	Malting and Brewing.
,,	,, 7,420.	Du Boulay, T., and J. J. C. Sheridan	Drying and screening malt.
1838.	,, 7,591.	Parker, A., and O. Byrne	Malt- and Liquor-gauge.
,,	,, 7,658.	Walker, P.	Automatic Beer-cleansing.
,,	,, 7,679.	Richardson, A.	Spirit from Malt.

1838.	No.	7,829.	Heath, M.	Filtration of Beer, &c.
„	„	8,013.	Grover, H. M.	Brewing from Barley-awns.
1840.	„	8,647.	Dean, A., and E. Evans	Malt-mill. [line.'
1841.	„	8,843.	Newton, W. E.	Extract of Hops 'Humu-
„	„	8,919.	Beilby, J.	High-pressure Boiler for Wort. [Gear.
„	„	8,921.	Tizard, W. L.	Mashing and Fermenting
1842.	„	9,475.	Stead, P.	Malting.
1843.	„	9,596.	Herbert, L.	Malt-mill.
„	„	9,648.	Bell, G.	Malt-drying.
„	„	9,736.	Poole, A.	Malt-drying.
„	„	9,767.	Knight, S. J.	Malt-kiln.
„	„	9,828.	Parsons, G., & R. Clyburn	Malt-rolls.
„	„	9,924.	Davison, R., and W. Symington	Cask-cleaning.
1844.	„	10,053.	Kurtz, A.	Heating Apparatus.
„	„	10,071.	Masterman, T.	Refrigerator.
„	„	10,419.	Ryan, J.	Fermenting Vat. [screw.
„	„	10,459.	Bell, G.	Malt-kiln: Archimedean-
1845.	„	10,641.	Maugham, W., and A. Dunlop, jun.	Brewing. [with Rye-malt.
„	„	10,829.	Meade, H. M.	Brewing Maize and Rye
„	„	10,962.	Chappell, N.	Mashing-process.
„	„	10,963.	Maugham, W., and A. Dunlop, jun.	Heating after Fermentation, Filtering, Aerating.
1846.	„	11,045.	Arney, G. A.	Fining and Clarifying.
„	„	11,166.	Hyde, S.	Refrigerator. [gines.
„	„	11,179.	Pickford, S.	Vats and Casks, Beer En-
„	„	11,268.	Moreland, J.	Fixing Coppers, Stills, &c.
1847.	„	11,563.	Vaux, C.	Store-vats.
„	„	11,565.	Du Boulay, T. and J.	Granaries. [menting tuns.
„	„	11,604.	Crosse, A.	Electric Currents in Fer-
„	„	11,998.	Maltby, W., & T. Webb	Removal of Oil from Barley for Distilling, &c.
1848.	„	12,043.	Collins, J.	Hop-winnow: Dessication of Air in Malt-kilns.
„	„	12,159.	Bursill, G. H., J. Paterson, and J. Matthews	Aerating Malt-liquor.
„	„	12,270.	Lillie, J.	Centrifugal-cooler.
„	„	12,328.	Adams, S.	Malt-mill. [ming.
„	„	12,344.	Lane, J., and J. Taylor	Refrigerating, and Skim-
„	„	12,411.	Wrigley, M.	Making Yeast.
1849.	„	12,439.	Johnson, R.	Malting and Brewing.
„	„	12,549.	Lawrence, J., sen.	Cooling; storing.
1851.	„	13,680.	Payne, C.	Cooling.
„	„	13,735.	Hallewell, B.	Malt-drying by gas-jets.
1852.	„	14,002.	Negretti, E. A. L., and J. W. Zambra	Areometers.
„	„	14,006.	Crockford, J.	Mashing.
„	„	14,015.	Kempen, P. V. (from G. A. Cramer)	Refrigerator. [lation.
„	„	14,119.	Tizard, W. L.	Malting: mashing: distil-
„	„	14,282.	Lawrence, J.	Mashing.
„	„	14,283.	James, W. H.	Heating and Refrigerating.
„	„	14,327.	Palin, J., & R. W. Sievier	Brewing.

1852.

[*Under the Patent Law Amendment Act*, 1852.]

No.	288.	Waller, A.	Testing Alcoholic Fluids.
,,	354.	Walker, J.	Malt Roller-mill.
,,	513.	Plimsoll, S.	Cleansing and Fining Malt-liquors.
,,	763.	Edwards, J. S.	Automatic Manifold Kiln.
,,	875.	Hudault, A. J. C.	Leaven.
,,	942.	Walker, P., and A. B. Walker	Fermentation.
,,	990.	Brooman, R. A.	Heating or Refrigerating.
,,	1,125.	Moore, E. D.	Condensing and Storing Wort.

1853.

No.	97.	Lillie, J.	Malt-conveyors (Endless Belts).
,,	106.	Vion, H. C.	Refrigerating Apparatus.
,,	400.	Ludlow, H. S.	Screening and Grading Malt.
,,	415.	Walker, M.	Cooling Jacket for Malt-liquors.
,,	471.	Lawrence, J.	Malt- or Grain-kiln (steam).
,,	522.	Moore, E. D.	Extraction, Condensation, and Storing of Wort.
,,	543.	Waterman, J.	Extracting Spent Hops.
,,	801.	Walker, W.	Malt-kiln (Air).
,,	1,009.	Plimsoll, S.	Cleansing and Fining Malt-liquors
,,	1,196.	Mertens, H. D.	Solidifying Wort.
,,	2,268.	Shears, D. T.	Vacuum-brewing-copper.
,,	2,614.	Steel, W.	Mashing Machinery.

1854.

No.	209.	Fournier, J. J. L.	Fermenting and Distilling Brewers' Grains, Returns, &c.
,,	490.	Johnson, T. J.	Malt-roaster.
,,	663.	Young, J.	Vacuum-copper; Suction-Draining [of Mash.
,,	815.	Condy, H. B.	Concentrating Malt-liquors, &c.
,,	963.	Tizard, W. L.	Drying and Roasting Malt.
,,	1,113.	Robertson, J. C.	Malt-roaster.
,,	1,413.	Collette, C. H.	Mashing and Fermenting Plant.
,,	1,509.	Beck, D.	Distilling Hop-aroma; Hopping in Cask: Saccharification by Acid.
,,	1,647.	Tizard, W. L.	Fermentation-plant.
,,	1,864.	Froggart, R. B.	Clarification.
,,	1,912.	Fontaine - Moreau, P. A.	Mashing, Fermenting, and Distilling Green Maize (Ear and Stem).
,,	1,957.	Youil, J.	Fermenting-plant.
,,	2,132.	Disher, J.	Mashing-gear.
,,	2,341.	Collis, W.	Hopping.
,,	2,387.	Loysel, E.	Mashing.
,,	2,726.	Nash, J.	Malting.

1855.

No.	106.	Riley, G.	False Bottoms for Tuns.
,,	423.	Gilbee, W. A.	Mashing, Fermenting, and Distilling Green Maize (Ear and Stem).
,,	737.	Botta, F. T.	Brewing-Plant and Process.
,,	882.	Manning, J. A.	Rousing by Air-currents.
,,	1,473.	Moreau-Darluc, C.	Extraction by Suction.

1855 (*continued*).

No. 1,489.	Weems, J.	Steam-heated Air-kiln.
,, 1,538.	Riley, G.	Cone-malt-mill.
,, 2,062.	Partridge, J., and J. Kirkham	Malt-rolls with Brush-gear.
,, 2,408.	Riley, G.	Differential Malt-rolls.
,, 2,454.	Lewis, J., & J. Edwards	Malt-mill Gear.
,, 2,533.	Green, E., & J. Green	Dust-tight Cased Malt-mill.
,, 2,565.	Robinson, J.	Drying by Superheated Steam.
,, 2,577.	Lister, G.	Refrigerator.
,, 2,600.	Fleetwood, J.	Portable Malting.

1856.

No. 65.	Pitman, J. T. (from F. V. O. Hyckert)	Saccharification by Diastase.
,, 110.	Bakewell, T. H.	Cooling.
,, 212.	Gardner, E. V.	Heating, Drying, and Evaporating.
,, 387.	Blackwell, T. E.	Cooling Worts.
,, 735.	Cliff, J.	Cask-cleaning.
,, 966.	Blackwell, T. E.	Hardening Water.
,, 1,471.	Riley, G.	Refrigerator.
,, 1,529.	Henley, T. F.	Steaming and Saccharifying Rice [for Fermentation.
,, 1,711.	Papineau, W.	Steaming and Saccharifying Starchy Matter with Acid for Fermentation.
,, 1,855.	Watt, W.	Malting Maize and other Grain.
,, 1,887.	Brooman, R. A.	Wheat-bran as Ferment.
,, 2,034.	Aron, M.	Pressed Yeast.
,, 2,110.	Riley, G.	Mashing Maize.
,, 2,228.	Winterbottom, R. jun.	Dry Yeast.
,, 2,364.	King, T.	Continuous Compressor for Spent [Hops, &c.
,, 2,415.	Tooth, A.	Bleaching Malt by Sulphur.
,, 2,482.	Potts, G. C.	Scouring Casks with Sand, &c.
,, 2,498.	White, G.	Steaming Raw Grain.
,, 2,619.	Dircks, H.	Grinding; Mashing Flour and Husk separately; extracting Hops apart [from Wort.
,, 2,641.	Barlow, A.	Mash-tun Gear, &c.
,, 2,758.	Tooth, C.	Racking.
,, 2,759.	Ludewig, F.	Leaven.
,, 2,814.	Walker, P.	Brewing-plant and Processes.
,, 2,994.	Renon, V. L. C.	Steaming and Saccharifying Rice.
,, 3,081.	Swain, W.	Air-kiln.

1857.

No. 59.	Pilkington, P., and T. Entwisle	Cask-washer.
,, 94.	Watt, W.	Steaming and Mashing Maize, &c.
,, 183.	Harris, T.	Refrigerating Machine.
,, 226.	Hensel, A.	Pressed Yeast.
,, 227.	Tizard, W. L.	Fermenting-plant.
,, 276.	Wright, A.	Steaming Malt before Drying.
,, 286.	Hensel, A.	Compressed Yeast.
,, 406.	Potts, G. C.	Cask-washer.
,, 496.	Grist, J.	Mash-tun.
,, 1,026.	Wiles, W. G.	Brewing-copper.
,, 1,310.	Francis, J. H., and R. Ord	Cask-washer.

1857 (*continued*).

No.	1,433.	Blacklidge, W., jun., and G. Read	Mashing-gear.
,,	1,456.	Travis, E., and Casartelli, J. L.	Automatic Regulator of Steam for [Boiling, &c.
,,	1,458.	Roberts, T. H.......	Cask-washer.
,,	1,638.	Daly, D. J.	Cask-vent-valve.
,,	1,818.	Lawrence, J.	False Bottom of Mash-tun; Yeast- [strainer.
,,	2,175.	Clark, W. S.	Hop-press.
,,	2,186.	Grist, J.	Manifold Mash-tun; Steam-boiling.
,,	2,362.	Harrison, J.........	Refrigerator.
,,	2,419.	Imhof, D.	Exhausting or Blowing-machines.
,,	2,448.	West, E. B.	Brewing-plant.
,,	2,632.	Plomley, J. C.	Malt-drying.
,,	2,684.	Tooth, C., and W. W. Wynne	Refrigerator.
,,	2,822.	Fordred, J.	Hardening Water.
,,	2,845.	Madden, P.	Manifold Malt-kiln.

1858.

No.	760.	Biebuyck, J. B., and J. van Landuyt	Fermenting Flour-paste.
,,	783.	Manbré, A.	Colouring for Beer, &c. from Glucose.
,,	1,011.	Bridgman, J.	Cooling by Ice, &c.
,,	1,079.	Dix, A. M.	Condensing Vapours, Refrigerating, [&c.
,,	1,271.	Manbré, A.	Malting and Mashing.
,,	1,283.	Lombard, J. B. A., and X. T. Esquiron....	Saccharification of Cereals.
,,	1,353.	Wilkins, W. P.	Refrigerator-tubes.
,,	1,441.	Tizard, W. L.	Mashing-gear.
,,	1,536.	Hodge, P. R.	Steaming Malt, Cutting Hops, Extraction and Refrigeration.
,,	1,695.	Long, J.............	Cooling.
,,	1,718.	Luis, J.	Cooling.
,,	1,759.	Steel, J.	Mashing, Boiling, and Hopping.
,,	1,888.	Plomley, J. C.	Joists under Kiln-floors.
,,	2,106.	Luis, J.	Centrifugal Separator for Yeast, &c.
,,	2,303.	Moore, T.	Refrigerator.
,,	2,364.	Kennedy, R., and J. Armstrong	Grain-kiln.
,,	2,453.	Blumberg, V.	Slate-veneered Vats.
,,	2,613.	Howe, G., & J. Norton	Steam Coils.
,,	2,617.	Vasserot, C. F. (from L. Fialon)........	Refrigerator.
,,	2,749.	Davis, A. E., and R. Wright	Colouring from Sugar.
,,	2,802.	Harris, J. J.........	Refrigerator.

1859.

No.	77.	White, J.	Cooling.
,,	290.	Waller, G. A.......	Yeast-press.
,,	320.	Brooman, R. A. (from Mme. Jolibois) ..	Cooling.
,,	371.	Herring, E.	Mashing and Fermenting Raw Grain.
,,	400.	Bennett, J., and J. Bennett	Refrigerators.
,,	451.	Garton, C.	Inverting Sugar.

1859 (*continued*).

No.	505.	Wagner, J. H. G. D.	Filtering Brewing Water.
„	679.	Larochette, P., sen.	Mashing Gear.
„	803.	Pickering, C.	Portable Brewing-plant.
„	930.	Coffey, J. A.	Heating by Steam.
„	935.	Luis, J. (from J. L. Baudelot)	Refrigerator.
„	999.	Van Hulst, A. F.	Malt-kiln.
„	1,055.	Fanshawe, H. R.	Airtight Racking, Filtering, and Gauging.
„	1,178.	Manbré, A.	Glucose-making.
„	1,179.	Manbré, A.	Colouring from Glucose.
„	1,338.	Clark, W. (from F. Ludewig)	Leaven.
„	1,375.	Gill, E.	Mashing Rice, Maize, &c.
„	1,417.	Henley, T. F.	Saccharifying Rice by Acid.
„	1,617.	Robinson, W.	Cask-washer.
„	1,627.	Mathews, D.	Refrigerating and Heating.
„	1,756.	Robertson, P.	CentrifugalYeast-andHop-separator
„	1,932.	Riley, G.	Helical Refrigerator.
„	2,005.	Goff, S. D., H. Davis, S. and E. Strangman	Air-kiln.
„	2,013.	Schramm, H. R. L.	Pressing Grains, &c., by Rolls.
„	2,027.	Tomell, V.	Yeast.
„	2,118.	Luis, J. (from J. L. Baudelot)	Refrigerator.
„	2,137.	Manbré, A.	Colouring from Glucose.
„	2,152.	Davison, R.	Refrigerators, &c.
„	2,294.	Robertson, P.	Pressure-mashing, Vacuum-boiling and Fermenting.
„	2,442.	McGlashan, A.	Refrigerator.
„	2,458.	Hodge, P. R.	Brewing-plant and Processes.
„	2,944.	Rul, L. J. G.	Instantaneous Cooling.

1860.

No.	118.	Brooman, R. A. (from B. Paraf-Javal)	Clarification.
„	298.	Robertson, P.	Wort-filter: Centrifugal Grains and Yeast-separators.
„	345.	Langford, J., and C. Chester	Cooling.
„	478.	Davison, R.	Steam-boiling.
„	538.	Shore, S. F.	Bunghole Plug.
„	859.	Jensen, A. N.	Brewing and Fermenting.
„	887.	Bridle, H.	Refrigerators.
„	923.	Hill, J.	Malt-screens.
„	1,143.	Geohegan, R.	Press for Grains, Hop or Yeast.
„	1,246.	Barker, W., jun.	Fermentation; Attemperator.
„	1,368.	Wateau, C.	Cooling Beer.
„	1,408.	Waller, G. A.	Yeast-press.
„	1,479.	Dressel, R., and A. Figge	Making Yeast.
„	1,614.	Harris, G. S.	Rapid Refrigerator.
„	1,749.	Davis, I. N.	Saccharification by Acid with Steam; Neutralisation by Chalk.
„	2,120.	Hollands, G.	Automatic Yeast Sluice.
„	2,258.	Teulon, W. H. (from A. C. L. Reinhardt)	Mashing and Cooling.

1860 (*continued*).

No.	2,266.	Hughes, E. J. (from J. C. Hendricke-Percy and J. F. Vandenhove)	Raw Grain Mashing and Cooling.
,,	2,331.	Geohegan, R.	Press for Yeast, Grains and Hops.
,,	2,461.	Barnett, T.	Malt-roaster.
,,	2,479.	Hanon, E. J.	Clarification with Vegetable Gluten.
,,	2,503.	Davies, G. (from F. P. E. Carre)	Refrigerating.
,,	2,611.	Boys, H.	Using Hop-bine as Hops.
,,	2,799.	Matthews, J.	Condensing Hop Vapours.
,,	2,934.	Jaques, J. A., J. A. Fanshawe, and G. Jaques	Cooling.
,,	3,034.	Cann, A. J.	Grinding and Crushing.

1861.

No.	11.	West, E. B. (from E. F. Andrews)	Brewing Plant.
,,	273.	Medlock, H.	Brewing Process.
,,	358.	Maltby, W.	Gelatinising Rice.
,,	365.	Roskilly, C. S.	Fining.
,,	534.	Haigh, T., and R. A. Robertson	Boiling, Cooling and Fermenting Plant.
,,	583.	Hollands, G.	Fermenting Plant.
,,	638.	Pontifex, E. A.	Charging Fermenting Vessels.
,,	775.	Vandecastelle, L. J.	Brewing.
,,	778.	Sorrell, W.	Mashing.
,,	792.	Medlock, H.	Sulphiting Liquors.
,,	1,353.	Blake, A.	Brewing.
,,	1,520.	Illingworth, J.	Breweries.
,,	1,662.	Wood, A.	Tuns.
,,	1,816.	Gallafent, D.	Refrigerators.
,,	1,858.	Wood, A.	Tuns.
,,	2,196.	Robertson, P.	Dry Yeast.
,,	2,407.	Tessier, J.	Mashing Raw Grain.
,,	2,435.	Lush, J.	Mash-tun Coils.
,,	2,503.	Sansum, J. E. J.	Mashing-gear.
,,	2,710.	Gibbon, R.	Malt-mill.
,,	2,798.	Gibson, H. G. (from J. Perrigault)	Drying "Mault."
,,	3,118.	Tonnar, A.	Drying Malt.
,,	3,179.	Pontifex, C.	Refrigerator.
,,	3,217.	Rosendell, J.	Yeast-press.

1862.

No.	564.	Robertson, P.	Dry Yeast.
,,	939.	Morton, R.	Refrigerator.
,,	1,028.	Mertens, G. D. (from C. T. Aulhorn)	Condensing and Storing Wort.
,,	1,169.	Elliott, C. E. (from G. Grosberger and H. C. Kurr)	Dry Yeast.
,,	1,256.	Tizard, W. L.	Cooling.
,,	1,295.	Walker, R.	Malting.
,,	1,395.	Oxley, J.	Mashing and Sparging.

1862 (*continued*).

No. 1,498.	Davison, R., and T. Johnson	Cask-washer.
,, 1,510.	Ramsden, R., jun.	Mashing-gear.
,, 1,613.	Boetius, H.	Refrigerating.
,, 1,974.	Pontifex, H. S.	Cask-washing.
,, 2,088.	King, T.	Malt-measurer.
,, 2,360.	Newton, W. E.	Mashing.
,, 2,434.	Garton, C.	Hot Fluid Coils in Malting and Brewing.
,, 2,491.	Ritchie, G.	Hop and Yeast Press.
,, 2,543.	Moreland, R., jun.	Hop-cutter.
,, 2,564.	Pontifex, C.	Hop and Yeast Press.
,, 2,706.	Oxley, J.	Yeast Press.
, 2,927.	Gregory, F.	Hop Press.
,, 3,032.	Newton, W. E. (from V. P. C. Baud)	Mashing Maize.
,, 3,192.	Browning, S. J.	Mashing and Refrigerating.
,, 3,396.	Thudichum, J. L. W.	Aerating Beer.
,, 3,470.	Johnston, J.	Refrigerator.

1863.

No. 1.	Collyer, R. H.	Mashing.
,, 306.	Jacobs, T. L.	Cask-cleaning.
,, 428.	Dibb, W. T.	Heating Malt before Mashing.
,, 553.	Fry, J.	Mashing.
,, 567.	Maxfield, J.	Floating Yeast-strainer.
,, 584.	Garton, C.	Hot Fluid Coils in Malting and Brewing.
,, 698.	Moreland, R.	Extracting Hops.
,, 876.	Johnson, J. H. (from G. H. Fourdrinier)	Malt-drying Cylinder.
,, 1,083.	Gretton, F.	Mash-tun Coils.
,, 1,345.	Jarvis, T.	Concentrating Wort.
,, 1,428.	Hills, G.	Condensing Aroma from Hop-kilns.
,, 1,448.	Hatschek, M.	Mashing Maize, &c.
,, 1,527.	Barker, D.	Press-yeast.
,, 1,539.	Watts, J.	Malting-cylinder.
,, 1,542.	Henry, M. (from J. Lemoine and L. J. M. Chollet)	Preparing Grain for Mashing, by Acid or Alkali.
,, 1,797.	Johnson, T.	Cask-washing.
,, 1,916.	Woods, H.	Attemperating Unions.
,, 1,997.	Ellis, J.	Scouring Malt.
,, 1,998.	Dennett, C. C.	Concrete Arches and Floors.
,, 2,037.	Dearn, A. M.	Centrifugal Disc-Masher.
,, 2,112.	Fry, J.	Mashing.
,, 2,247.	King, J.	Rousing.
,, 2,259.	Gossage, W.	Drying and Curing Hops.
,, 2,270.	Dannatt, J.	Cooling.
,, 2,312.	Pooley, J. C.	Distilling Wort.
,, 2,336.	Maitland, C.	Mashing-gear.
,, 2,438.	Towlson, J.	Cooling.
,, 2,439.	Pepper, R.	Hop-press.
,, 2,602.	Weems, J.	Steam- or Hot-air-Drying of Grain, Malt, &c.
,, 2,646.	Blake, A.	Refrigerator.
,, 2,939.	Hamper, D. W.	Mashing-gear; Thermometer on liquor-pipe.
,, 3,032.	Clifton, R. L.	Mashing-plant.

1864.

No.	101.	Murphy, W. J.	Copper.
„	194.	Bright, T.	Malt-kiln Flues.
„	235.	Fry, J.	Mashing-gear.
„	250.	Heathorn, T. M.	Yeast-press.
„	322.	Taylor, W. R.	Enamelled-iron Vessels.
„	426.	Jude, J. B.	Cask-washer.
„	507.	Mellor, W. H.	Fermenting Unions.
„	552.	Manbré, A.	Saccharification by Acid.
„	701.	Jude, J. B.	Yeast-press.
„	745.	Garton, C., & T. Hill	Mashing-gear.
„	877.	Picking, J.	Refrigerators.
„	1,024.	Worssam, G. J.	Yeast-press.
„	1,123.	McVitie, W.	Refrigerator.
„	1,177.	Roy, J.	Automatic Mashing-gear.
„	1,178.	Newton, A. V. (from L. Wiart)	Rapid Cooling.
„	1,308.	Stévenaux, L.	Sweating and Drying.
„	1,370.	Mellor, W. H.	Automatic Mashing-gear.
„	1,406.	Loysel, E.	Extractive Mashing.
„	1,599.	Stevens, B. F. (from S. Stevens)	Drying Malt and Hops with Petroleum, &c., as fuel.
„	1,624.	Frielinghaus, C. (from Ignatz Beu)	Making Yeast.
„	1,695.	Blake, A.	Hardening Water for Brewing.
„	1,718.	Newton, A. V. (from J. Schneuhr)	Water Measurer to Mash Tun.
„	1,841.	Gregory, F.	Mashing-gear: Cask-washer.
„	1,931.	Garton, C., & T. Hill	Mashing-gear.
„	2,177.	Walker, D.	Manifold Malting.
„	2,222.	Williams, J.	Fixing Unions.
„	2,298.	Lawrence, W.	Mashing and Cooling.
„	2,394.	Watts, J.	Floating Yeast Separator.
„	2,420.	Loysel, E.	Mashing.
„	2,535.	Watts, J.	Floating Yeast Separator.
„	2,598.	Tizard, W. L.	Cooling and Aerating Wort; Yeast-filter.
„	2,719.	Garton, C., & T. Hill	Cooled Pure Air in Brewing, Racking, &c.
„	2,834.	Gardner, R.	Continuous Wrought-iron Boilers.
„	2,923.	Millns, F.	Cooling-wort.

1865.

No.	249.	Burg, V.	Filtration of Beer, &c.
„	306.	Webb, J. R. (from G. Percy, W. Wells, C. Brown, J. Mulford, and J. M. Webb)	Concentrating Hop Extract.
„	481.	Willison, R.	Automatic Mashing-gear.
„	572.	Barth, G. H.	Refrigerating.
„	719.	Newton, A. V. (from D. Somes)	Cooling by Water passed below Earth's Surface.
„	799.	Coleman, W. J.	Clarifying.
„	1,204.	Gregory, F.	Mashing and Sparging.
„	1,227.	Wise, F. (from B. G. Martin)	Hop-decoction.

1865 (*continued*).

No. 1,249.	Hampton, J.	Refrigerator.
„ 1,263.	Bennett, S.	Mashing, &c.
„ 1,297.	Forbes, J.	Fan-exhaust to Malt-kiln.
„ 1,700.	Ashby, M.	Refrigerator.
„ 1,781.	Prideaux, J. S.	Aeration of Beer, &c.
„ 1,963.	Latham, B., and R. Campbell	Hop-kiln with Fans & Turning Gear.
„ 1,972.	Robinson, B., and J. Varley	Brewers' Furnaces.
„ 2,019.	Robertson, P.	Mashing and Cooling: Drying Yeast.
„ 2,096.	Westley, R. A. W. (from H. Pinkus)	Store-vats. [Drawn Liquor.
„ 2,187.	Watkins, C. A.	Carbonic Acid Gas to Replace
„ 2,492.	Davis, C. E.	Locked Wire-covers to Steep-cisterns. [Drawn Liquor.
„ 2,660.	Mott, A. J.	Carbonic Acid Gas to Replace
„ 3,047.	Newman, C. H.	Mashing.
„ 3,087.	Taylor, W. R.	Continuous Flow and Agitation in Steep; Antiseptic Sprinkling; Yellow Light to Maltings.

1866.

No. 115.	Wheeler, N. W.	Refrigerating.
„ 302.	Miller, J., and J. Pyle	Cooling.
„ 615.	Dufrené, H. A. (from C. Tellier)	Cooling.
„ 747.	Severn, G.	Cooling.
„ 905.	Ryder, T.	Mashing.
„ 985.	Taylor, W. R., and G. Hewett	Warming Steeping-water; Washing Raw Grain; Antiseptics in Steep and Sprinkling; Yellow Light; India-rubber Shovels or Tips to Wood; Turning Machinery on Floors.
„ 1,235.	Gretton, F.	Screening Malt.
„ 1,326.	Johnson, J. H. (from J. Foley)	Drying and Cooling Grain and Malt.
„ 1,398.	Hampton, J.	Brewing-furnace.
„ 1,445.	Gripper, E.	Patent Malt from Grains.
„ 1,499.	Haigh, T.	Coolers.
„ 1,508.	Pontifex, E. A.	Refrigerators.
„ 1,559.	Lawrence, W.	Malting.
„ 1,560.	Lawrence, W.	Straining and Cooling Wort.
„ 1,834.	Roberts, M. J.	Cooling.
„ 2,204.	Dufrené, H. A. (from C. Tellier)	Cooling.
„ 2,241.	Newton, H. E. (from E. Velten)	[and Cooling. Preserving Beer by Rapid Heating
„ 2,298.	Schneider, J.	Brewing. [ing.
„ 2,416.	Walker, A. B.	Attemperation in Malting and Brew-
„ 2,526.	Dix, A. M.	Refrigerators.
„ 2,846.	Edwards, O. C.	Cask-washer.
„ 3,083.	Potter, R.	Washing Grain with Antiseptics.
„ 3,391.	Allen, E.	Cask-washing.

1866 (*continued*).

No. 3,422.	Slatter, J.	Malt-screen.
„ 3,433.	Napier, J.	Malt Substitute, Barley- or Oat-Straw-chaff and Whole Grain, Steamed, Pressed, and Dried.

1867.

No. 57.	Winder, R.	Pocketting Hops.
„ 130.	Hamper, D. W.	Finings.
„ 249.	Prideaux, T.	Malt-kilns.
„ 330.	Waller, G. A.	Beer-filter.
„ 520.	Samson, W. H.	Hop-drying.
„ 787.	Gregory, F.	Refrigerating.
„ 1,150.	Millward, J. (from J. Walker)	Mash-tuns.
„ 1,267.	Norton, J. L.	Drying Grains, Hops, &c.
„ 1,289.	Ritchie, C.	Storing and Drawing Liquors.
„ 1,380.	Ritchie, C.	Casks.
„ 1,427.	Clark, A. M. (from P. L. Margot)	Raising Liquors.
„ 1,485.	Norton, J. L.	Drying Malt, Grains, &c.
„ 1,698.	Crompton, J.	Revivifying Malt Liquor.
„ 1,738.	Askew, C.	Refrigerating.
„ 1,751.	Clark, A. M. (from A. C. J. Lengelée and P. R. Rozee)	Cooling.
„ 1,988.	Severn, G.	Refrigerators.
„ 2,031.	Stirk, J. & H. Bycroft	Refrigerators.
„ 2,071.	Norton, J. L.	Drying Grain, Malt, &c.
„ 2,081.	Fleming, J.	Raising Beer, &c.
„ 2,095.	Schofield, J., and J. C. Dawson	Malting and Drying.
„ 2,125.	Bromwich, T.	Ventilating Maltings.
„ 2,132.	Breithaupt, T. A. ..	Essence of Hops.
„ 2,137.	Newton, W. E. (from W. S. Haight) ..	Brewing.
„ 2,258.	Dale, J.	Refrigerator.
„ 2,330.	Flower, C. E.	Cooling.
„ 2,540.	Woods, H.	Hop-press.
„ 2,652.	Hall, W.	Separating Yeast.
„ 2,707.	Oxley, J.	Refrigerator.
„ 2,760.	Allibon, G., and A. Manbré	Saccharification.
„ 2,804.	Williamson, J. S. ..	Drying Corn, Malt, &c.
„ 2,944.	Schwartz, J.	Refrigerating.
„ 2,976.	Welton, T.	Ozonisation of Growing Malt, &c.
„ 3,124.	McDougall, A.	Turning Malt.
„ 3,359.	Belknap, E.	Treating Wort.

1868.

No. 72.	Pontifex, C.	Hop-press.
„ 86.	Newman, C. H.	Unfermented Malt-liquor.
„ 171.	Winter, J., jun.	Bottling and Corking.
„ 212.	Coleman, W. J.	Finings.
„ 228.	Bennett, S.	Drying Grain, Grains, &c.
„ 360.	Weems, J., and W. ..	Drying Grain, Malt, &c.

1868 (*continued*).

No.	377.	Morton, R.	Refrigerators.
,,	861.	Rowand, M.	Treatment of Malt.
,,	898.	Smith, R.	Drawing Gas from Vats.
,,	1,009.	McGlashan, A., and J. Henry	Mashing-gear.
,,	1,082.	Walker, A. B.	Evaporating.
,,	1,254.	Kitto, G. D., and P. Brotherhood ..	Refrigerating.
,,	1,535.	Dix, A. M.	Fining.
,,	1,624.	Needham, W., and J. Kite	Filtering-surfaces.
,,	1,701.	Seck, W.	Grain-kilns.
,,	1,760.	Newton, W. E. (from W. S. Haight)	Hopping Beer.
,,	1,937.	Muller, W., and G. Englert	Cooling Beer.
,,	1,965.	Turrell, G. B.	Cooling Beer, &c.
,,	2,274.	Beanes, E.	Brewing.
,,	2,375.	Herring, E.	Saccharine.
,,	2,408.	Kitto, G. D., and P. Brotherhood ..	Cooling.
,,	2,558.	Espeut, W. B.	Drying Grains, &c.
,,	2,561.	Beanes, E.	Finings.
,,	2,590.	Davey, W. H.	Drying Malt.
,,	2,602.	Haigh, T.	Brewing Plant.
,,	2,820.	Seebohm-Ultzen, F. (fromHaas-Demrath)	Aeration, Preservation, and Elevation of Beer.
,,	2,930.	Woods, H.	Steam-boiling.
,,	3,081.	Steel, J.	Extracting Roasted Malt.
,,	3,278.	Mort, W.	Cooling.
,,	3,314.	Wallwork, H.	Taps.
,,	3,507.	Drayson, A. W.	Cooling.
,,	3,936.	Boby, R.	Malt-kiln Floors.
,,	3,976.	Bonneville, H. A. (from J. Gecmen)..	Malting and Drying.

1869.

No.	70.	Saunders, M., and H. Forrest	Refrigerators.
,,	84.	Matthews, F. C.	Treating Maize.
,,	122.	Steel, J.	Cask-washing.
,,	178.	Siddeley, J., and F. M. Mackay	Cooling.
,,	230.	Newton, A. V. (from R. d'Heureuse)	Germinating.
,,	381.	Strauss, L., and A. Seckbach (from W. Eichman)	Treating and Raising Beer.
,,	470.	Houdaille, V. A.	Vat-bungs.
,,	539.	Weems, J., and W. ..	Malting and Drying.
,,	727.	Spencer, G., and J. Barker	Preserving Malt, &c.
,,	738.	Spencer, G.	Preserving Malt.
,,	741.	Bernier, J. B.	Preserving Yeast.
,,	832.	Walker, A. B.	Drying Malt.

1869 (*continued*).

No.	847.	Hamilton, J., and R. Paterson	Manipulating Liquors.
,,	920.	Kirk, A. C.	Cooling.
,,	1,083.	Dewar, J.	Treating Grains.
,,	1,121.	Beanes, E.	Sulphites for Brewing.
,,	1,174.	Whitehurst, F. F.	Mashing-gear.
,,	1,219.	Hodge, P. R.	Brewery-hose.
,,	1,354.	Shackleton, J.	Steam-boiling.
,,	1,370.	Gedge, W. E. (from F. Foussart, jun.)	Elevation and Preservation of Beer [by Gas.
,,	1,595.	Gilbee, W. A. (from E. D. Brainard)	Refrigerators.
,,	1,694.	Bindley, W. A.	Attemperator for Union-casks.
,,	1,893.	Olsson, M. (from H. Gahn and E. E. Edgvish)	Preserving Malt Liquors.
,,	1,897.	Manbré, A.	Saccharification.
,,	2,092.	Dewar, J.	Treating Spent Hops.
,,	2,212.	Johnson, J. H. (from H. Burgess)	Hop-extract.
,,	2,227.	Gilbee, W. A. (from E. D. Brainard)	Preserving Hop Aroma.
,,	2,406.	Needham, F. H.	Preserving Liquor in Cask.
,,	2,462.	Jenkins, J.	Cask-enamel.
,,	2,519.	Valters, J.	Finings.
,,	2,867.	Heathorn, A.	Yeast.
,,	2,906.	Pontifex, E. A.	Refrigerators.
,,	2,981.	Ellis, R. J.	Malt-drying.
,,	3,073.	Goodbody, R. J., and R. E. Donovan	Malt-drying.
,,	3,248.	McCormick, J.	Brewing.
,,	3,327.	Shelley, M.	Vent-peg.
,,	3,469.	Milburn, R., and T. Browning	Drying Grain, Malt, Grains, &c.
,,	3,474.	Forbes, J.	Drying Malt, Grain, &c.
,,	3,561.	Hamilton, J., and R. Paterson	Collapsible Casks.
,,	3,613.	Morton, R.	Refrigerators.
,,	3,621.	Moss, E. (from C. T. Klemm)	Malt-kilns.
,,	3,625.	Askew, J.	Refrigerator.
,,	3,661.	Martin, J. C.	Finings.
,,	3,669.	Shiels, J. M.	Malting.
,,	3,671.	Giles, S.	Fermenting-plant.
,,	3,785.	Bolton, F. J.	Treating Fermented Liquors.

1870.

No.	205.	Garton, W.	Saccharum.
,,	241.	Coleman, W. J.	Neutralising Beer.
,,	260.	Dewar, J.	Treating Liquid Refuse from Grains
,,	267.	West, H. J.	Cooling.
,,	358.	Ward, J., & J. Bowing	Yeast.
,,	387.	Stanley, J. M., and W. Atkins	Brewery-furnaces.
,,	389.	Pontifex, C. and F., and A. Sherwood	Hop-press.

1870 (*continued*).

No.	721.	Wright, J.	Sprinkling-can.
„	769.	Newton, W. E. (from R. Overbeck)	Malt-kilns.
„	871.	Watson, L., & J. Hall	Brewery-hoists.
„	895.	Bailey, W.	Brewing.
„	939.	Reis, A. B.	Preserving Beer.
„	966.	Jackson, H.	Drying Grain, Malt, &c.
„	989.	Winter, J., jun.	Bottling and Corking.
„	1,029.	Clinch, C.	Cleansing-beer.
„	1,062.	Newman, C. H.	Unfermented Malt-liquor.
„	1,160.	Bigot, R. F.	Venting Bung.
„	1,180.	Lungley, C.	Refrigerator-taps.
„	1,213.	Ortner, F. J.	Drawing from Casks.
„	1,249.	Stanbridge, S. W.	Preparing Malt.
„	1,275.	Matthews, C. P.	Cask-enamel.
„	1,336.	Lake, W. R. (from J. McCormick)	Brewing.
„	1,371.	Heddle, J.	Clarifying.
„	1,386.	Warne, J.	Cooling.
„	1,481.	Heath, W. E.	Cooling.
„	1,579.	Mignot, L.	Refrigerating.
„	1,774.	Boland, P.	Yeast.
„	1,814.	Morton, R.	Cooling.
„	1,895.	Carr, T.	Malt-mill.
„	1,969.	Maximos, N.C. (from A. R. P. H. Merrill, R. Heneage, and H. Spendelow)	Drying Malt, Grain, &c.
„	1,973.	Coffey, J. A.	Roasting Malt, &c.
„	1,994.	Wilson, H.	Cooling.
„	2,021.	Terry, St. G. A. (from A. Terry)	Finings.
„	2,045.	Hopkins, T. M.	Drying Malt, &c.
„	2,145.	Gibbs, W. A.	Drying Products.
„	2,231.	Bennett, S.	Worts.
„	2,245.	Gale, J., & H. Ormston	Finings-machine.
„	2,429.	Silcock, W.	Grain-screen.
„	2,522.	Frankenberg, A.	Raising and Drawing Beer.
„	2,618.	Head, F. J.	Beer Taps.
„	2,673.	Frankenberg, A.	Refrigerating.
„	2,842.	Rennie, J., and T. Halliday	Furnaces for Coppers.
„	2,891.	Reece, R.	Cooling.
„	2,918.	Meilee, C. W., and T. W. Smith	Tapping Barrels.
„	2,943.	Newton, W. E. (from C. A. Seely)	Hop-extract.
„	2,969.	Herring, E. (from B. Child)	Sulphited Finings.
„	2,987.	Kendall, I. S.	Cask-enamel.
„	3,076.	Read, W. T.	Purifying Beer.
„	3,210.	Mort, W. (from E. D. Nicolle and T. S. Mort)	Cooling.
„	3,264.	Gillman, A. W., and S. Spencer	Fining and Preserving Beer, &c.

1870 (*continued*).

No. 3,296.	Gamgee, J.	Refrigerators.
,, 3,351.	Calvert, C. A.	Drawing Off and Measuring Liquids.

1871.

No. 54.	Hydes, T., and J. and J. E. Bennett	Cooling.
,, 541.	Rennie, J.	Boiling-furnaces.
,, 607.	Gillman, A. W., and S. Spencer	Brewing.
,, 793.	Wilson, P.	Bushes.
,, 835.	West, H. J.	Bushes.
,, 876.	Rock, J.	Drying.
,, 962.	Halliday, T.	Brewery Furnaces.
,, 975.	Steel, J., and H. Wilson	Refrigerators.
,, 992.	Murdoch, H. H. (from E. Röttger)	Refrigerator.
,, 993.	Spencer, G.	Grain and Malt Bins.
,, 1,078.	Pontifex, C., F. Pontifex and A. Sherwood	Cask-washing.
,, 1,203.	Stapfer, H., and S. Stapfer	Drawing and Raising Beer.
,, 1,232.	Garton, W.	Saccharum.
,, 1,390.	Smith, J. W.	Fermentation.
,, 1,480.	Turnock, J.	Attemperator.
,, 1,651.	Mowbray, R.	Treating Maize.
,, 1,891.	Andrews, G.	Drawing from Casks.
,, 1,970.	Granville, W. L.	Corking-machine.
,, 2,040.	Curtis, W. J.	Extracting.
,, 2,095.	Bonneville, H. A.	Bottling.
,, 2,001.	Matthews, C. P.	Brewing.
,, 2,113.	Pearson, T. C.	Cask-tilt (Automatic).
,, 2,225.	Pasteur, L.	Brewing.
,, 2,290.	Leadbetter, J.	Brewing-pans.
,, 2,571.	Norton, J. L.	Drying Grain, Malt, &c.
,, 2,650.	Cole, T.	Vent-pegs.
,, 2,716.	Howlett, P. J.	Vent-pegs.
,, 3,026.	Willison, R.	Refrigerators.
,, 3,200.	Gregory, E.	Improving Beer.
,, 3,291.	Stanley, R. and J.	Malt-kiln Tiles.

1872.

No. 9.	Geohegan, S.	Cask-brander.
,, 130.	Davis, W.	Automatic Vent-pegs.
,, 190.	Gaskell, P.	Beer-pump.
,, 198.	Banolas-Arnau, R.	Register-tap.
,, 314.	Gibbs, W. A., and A. Borwick	Drying
,, 327.	Curtis, W. J.	Infusion-extract.
,, 329.	Lake, W. R. (from D. A. Clarke)	Preserving Hops.
,, 376.	Bonneville, H. A. (from E. Beckman-Olofson)	Rye-malt Brewing.

1872 (*continued*).

No.	439.	Notara, C.	Separator.
„	502.	Bell, A., & J. Walker	Brewing-coils.
„	750.	Johnson, J. H. (from J. J. Hignette)	Separator.
„	865.	Werner, J.	Cask-enamel.
„	899.	Garton, W.	Preparation of Brewing-material.
„	912.	Trimmer, W.	Glass Cask-head.
„	1,013.	Coales, F.	Brewing-material.
„	1,203.	Barlow, H. B. (from A. Naegeli)	Cooling.
„	1,382.	Johnson, J. H. (from G. M. Wells)	Curing Grain.
„	1,396.	Turner, H.	Wire Floors.
„	1,455.	Johnson, D.	Cleaning Grain.
„	1,586.	Lake, W. R. (from H. C. Cavaye)	Treating Maize.
„	1,630.	Corbett, T.	Dressing Grain.
„	1,702.	Northcote, G. B., jun.	Cask Gauge.
„	1,803.	Ray, A. (from P. M. Perrellon)	Cask-valve.
„	1,821.	Perry, A.	Drying and Roasting Malt, &c.
„	1,835.	Gooding, R. A.	Measuring Tap.
„	1,911.	Norton, J. L., and J. H. Carter	Treating Grain.
„	2,054.	Johnson, J. H. (from P. Nezeraux)	Cooling.
„	2,060.	Vogan, J.	Blast Elevator.
„	2,108.	Smith, G.	Air-filter to Casks.
„	2,180.	Conron, P. R.	Mashing-gear.
„	2,188.	Lake, W. R. (from J. Harris)	Elevator.
„	2,192.	Benson, M. (from S. Howes, A. & N. Babcock, and C. Ewell)	Smutter and Separator.
„	2,266.	Milburn, R., and H. Jackson	Drying.
„	2,351.	Moore, G. M.	Heating and Cooling.
„	2,365.	Hadley, S. H. (from P. Cardailhac)	Cleaning Grain.
„	2,366.	Lane, J., and W. Onions	Malt-rolls.
„	2,395.	Williams, J. G.	Brewing.
„	2,405.	McKinlay, P.	Treating Rice, &c.
„	2,516.	McFarlane, T. D.	Blast Conveyor.
„	2,548.	Bryce, A.	Cask-brander.
„	2,691.	Tomlinson, B.	Dressing Grain.
„	2,752.	Smyth, A., and C. T. Ramsay	Belt-drying.
„	2,879.	Adam, J. L.	Tap.
„	2,928.	Hickman, J. W.	Taps.
„	3,041.	Steel, J.	Cooling.
„	3,073.	Hamilton, J., and R. Paterson	Racking.
„	3,080.	Bethell, H.	Neutralising Beer.
„	3,107.	Ellington, E. B., and J. L. Liddell	Elevator-hoppers.

1872 (*continued*).

No.	3,372.	Read, W. T.	Bottling.
,,	3,389.	Mills, B. J. B. (from J. F. Wood and F. F. Skinner)	Smutter.
,,	3,449.	Davison, R.	Brewing Plant.
,,	3,475.	Ure, J. M.	Measuring Tap.
,,	3,483.	Johnson, S.	Tap-strainer.
,,	3,486.	Johnson, J. H. (from A. Hunter and E. H. Osborn)	Separators.
,,	3,708.	Weston, J. H.	Vent-peg.
,,	3,833.	Thorp, T.	Bush-valve.
,,	3,956.	Johnson, J. H. (from E. Leconte)	Treating Maize.
,,	3,960.	Cornish, K. H., and A. Strange	Casks.

1873.

No.	202.	Gedge, W. E. (from A. Gouesclain)	Tap and Vent-peg.
,,	418.	Chambers, R.	Cleaning Grain.
,,	536.	Marsters, S.	Cooling.
,,	599.	Sutton, C. W.	Neutralising Beer, &c.
,,	640.	Fremlin, R. J.	Cleansing and Seasoning Casks.
,,	737.	Marsters, S.	Cooling.
,,	821.	Phillips, G.	Roasting Malt, &c.
,,	954.	Paterson, R.	Collapsible Casks.
,,	998.	Hare, E.& J.O.Ardron	Grain-screens.
,,	1,010.	Fremlin, R. J.	Cleansing and Seasoning Casks.
,,	1,044.	Pearse, E. E.	Glucose.
,,	1,083.	Lawrence, W.	Cooling.
,,	1,106.	Clark, A. M. (from L. Pasteur)	Preserving Beer.
,,	1,130.	Barlow, H. B. (from N. J. Galland)	Cleaning Casks.
,,	1,346.	Barlow, H. B. (from N. J. Galland)	Cooling.
,,	1,382.	Hockley, W.	Cask-enamel.
,,	1,392.	Faulkner, J. H., and W. Tatters	Measuring-taps.
,,	1,443.	Barlow, H. B. (from N. J. Galland)	Cooling.
,,	1,529.	Lyon, H., and E. Robinson	Vat-float and Bell.
,,	1,551.	Dobelle, A.	Separator.
,,	1,612.	Lees, S. S., and F. Faulkner	Rousing-gear.
,,	2,029.	Beanes, E.	Checking Fermentation.
,,	2,042.	Hatschek, M.	Brewing.
,,	2,075.	Guenard, J.	Drying Grain, &c.
,,	2,155.	West, H. J. (from H. Whymper)	Filling Casks.
,,	2,215.	Ager, N.	Bush.
,,	2,300.	Boby, R.	Separator.
,,	2,436.	Swonnell, G. H.	Malt-kiln fired with Chalk.
,,	2,470.	Wright, E. G.	Cutting Finings.

1873 (*continued*).

No. 2,500.	Neubecker, A.	Refrigerators.
,, 2,513.	McKay, M.	Cask-enamel.
,, 2,547.	Murdoch. H. H. (from C. Haggermacher)	Cleaning Grain.
,, 2,619.	Chambers, R.	Cleaning Grain.
,, 2,682.	Wetherill, J.	Drying Malt, Grain, &c.
,, 2,729.	Clarke, J. P.	Preserving Bungs.
,, 2,806.	Staniland, J. T.	Restoring Screens.
,, 2,850.	Purnell, J. J., and R. Gorrill	Bush.
,, 2,929.	Gedge, W. E. (from A. A. Balat)	Cleaning Grain.
,, 3,009.	Baker, T.	Bung-hole Caps.
,, 3,018.	Marsden, E.	Boiling.
,, 3,056.	Gillman, A. W., and S. Spencer	Neutralising Beer.
,, 3,068.	Buchholz, J. A. A.	Bruising Grain.
,, 3,074.	Smith, R., jun.	Decorticating Rice, &c.
,, 3,098.	Gray, J. W.	Decorticating Rice, &c.
,, 3,127.	Blott, A. F.	Tap.
,, 3,294.	Wirth, F. (from A. V. Schlemmer)	Malt-turner.
,, 3,392.	Ambler, W., and W. Gawthorp	Tap.
,, 3,456.	Branson, W. P.	Roasting Malt, &c.
,, 3,482.	Symington, R. S.	Heat-record and Alarm.
,, 3,605.	Haycraft, G.	Cask-washing.
,, 3,877.	Tooth, A.	Treating Beer.
,, 4,203.	Hodson, W.	Glass Swan-necks for Union-Casks.
,, 4,266.	Allin, S. S.	Dressing Grain.

1874.

No. 50.	Gibbs, W. A.	Drying.
,, 55.	Perry, R. G.	Kilns for Malt, &c.
,, 222.	Whalley, J.	Decorticating Rice.
,, 289.	Lockwood, P. E.	Concentrating Beer.
,, 383.	Harrison, J.	Refrigerator, &c.
,, 480.	Clark, A. M. (from L. Chiozza)	Treating Maize.
,, 508.	Garton, W.	Treating Grains.
,, 678.	Barlow, H. B. (from N. J. Galland)	Malting and Brewing.
,, 1,031.	Webb, C. B. S.	Cask-filling.
,, 1,168.	Russ, E.	Taps.
,, 1,196.	Morgan, F.	Cask-piston.
,, 1,242.	Wise, W. L. (from J. Sboril)	Malting.
,, 1,361.	Southby, E. R.	Neutralising Beer.
,, 1,488.	Pye, T. B.	Fermentation.
,, 1,498.	Prentice, T.	Grain-screen.
,, 1,543.	Wilsher, H. B.	Coupling Beer-pump to Casks.
,, 1,693.	Twigge, N	Rice-cleansing.
,, 1,694.	Clark, A. (from C. L. Ridgway)	Cooling Beer.

1874 (*continued*).

No. 1,705.	Clark, A. M. (from J. L. Troster)	Concentrated Wort.
„ 1,758.	Hartley, J.	Fermentation-vats.
„ 1,801.	Henderson, A. G., and D. Ritchie	Refrigerators.
„ 1,882.	Rainforth, W. & W.	Grain-screens.
„ 1,988.	Barlow, H. B. (from N. J. Galland)	Malting.
„ 2,083.	Johnson, J. H. (from T. A. Breithaupt)	Hop-preserving.
„ 2,116.	Houghton, W.	Cleaning Grain.
„ 2,387.	Pooley, J. C.	Malt-bread, &c.
„ 2,447.	Taylor, R. S.	Taps.
„ 2,559.	Perry, A.	Roasting Malt.
„ 2,937.	Sainty, J.	Dressing Grain.
„ 2,991.	Bycroft, H.	Cooling.
„ 3,121.	Throop, J. W. (from G. E. Throop)	Cleaning Grain.
„ 3,123.	Edwards, J.	Taps.
„ 3,208.	Wise, W. L. (from J. Zboril [Sboril])	Malting.
„ 3,309.	Sezille, A.	Decortication by Acid.
„ 3,372.	Webb, C. B. S.	Racking.
„ 3,524.	Wirth, F. (from A. Stenger and A. Walker)	Malting.
„ 3,598.	Perry, R. G.	Drying Malt, Grains, &c.
„ 3,639.	Manbré, P. L.	Saccharification by Acid.
„ 3,731.	Cressey, T. S.	Malt-screen.
„ 3,796.	Marsh, W. R.	Treating Rice.
„ 3,810.	Marsh, W. R.	Treating Rice.
„ 3,811.	Marsh, W. R.	Treating Rice.
„ 3,909.	O'Sullivan, C., & W. G. Valentin	Dextrine-maltose.
„ 3,950.	Garton, W.	Glucose.
„ 3,982.	Laubarede, C. (from V. P. C. Baud and A. A. Saulxures)	Maize-brewing.
„ 4,127.	Shanks, W.	Floating Mouth to Beer-Syphon.
„ 4,170.	Buchholz, J. A. A.	Decorticating Grain.
„ 4,180.	Bruce, W.	Fining and Bottling Beer.
„ 4,289.	Chambers, R.	Cleaning Grain.
„ 4,312.	Read, W. T.	Sulphate of Magnesia.

1875.

No. 69.	Ellis, T.	Drying Yeast.
„ 213.	Shand, G.	Maturing Beer, &c.
„ 234.	Gillman, A. W., and S. Spencer	Aerating and Bottling Beer.
„ 237.	Clark, A. M. (from L. Macqué)	Grain-mill.
„ 351.	Weatherby, C. P. N.	Refrigerators.
„ 381.	Johnson, J. H. (from W. Adamson)	Treating Starchy Matter.
„ 579.	Manbré, A.	Extraction of Oil from Cereals, &c.

1875 (*continued*).

No.	601.	Cutler, W.	Glass-lined Fermenting Vessels.
„	708.	Sainty, J.	Dressing Grain.
„	732.	Van Gelder, P.	Dressing Grain.
„	761.	Lake, W. R. (from H. W. Shepard and R. Seamen)	Air-regulator.
„	775.	Gooch, Sir F. S.	Electro-regulation of Refrigerators.
„	810.	Johnson, S. H.	Glucose.
„	908.	Higginbottom, J., and E. Hutchinson	Cleaning Grain.
„	1,073.	McKay, F. N.	Cooling Malt-floors.
„	1,083.	Lessware, J. N.	Conversion.
„	1,193.	Higginbottom, J., and E. Hutchinson	Cleaning Grain.
„	1,489.	Pearse, E. E.	Glucose.
„	1,530.	Turnock, J.	Attemperator.
„	1,724.	Manbré, A.	Glucose.
„	1,774.	Richardson, C.	Solution of Saccharines.
„	1,806.	Brown, H. T.	Hop-sparging.
„	1,886.	Walker, A. B.	Brewing-gear.
„	1,887.	Walker, A. B.	Casks.
„	1,894.	Savill, E.	Skimming.
„	1,911.	Higginbottom, J., and E. Hutchinson	Cleaning Grain.
„	1,971.	Kunkler, E.	Malting.
„	2,007.	Clark, A. M. (from L. Chiozza)	Extracting Oil from Grain.
„	2,027.	Eli, A. J.	Drawing from Casks.
„	2,138.	Wise, W. L. (from L. Herrmann)	Malt-kiln Floors.
„	2,238.	Butterworth, A.	Beer-engine Tap.
„	2,268.	Fordred, J.	Malt-food for Stock.
„	2,293.	Leatherland, J.	Dressing Grain.
„	2,340.	Waron, M., and F. W. Willcox	Fan.
„	2,435.	Severn, G.	Refrigerators.
„	2,471.	Sézille, A.	Malting.
„	2,506.	Rose, H. J. F.	Separator.
„	2,609.	Dixon, F.	Seasoning Casks.
„	2,692.	Bone, W.	Gleaning Grain.
„	2,702.	Gillman, A. W., and S. Spencer	Bottling.
„	2,712.	Gibbons, C. B., and R. Allison	Preserving Beer.
„	2,766.	Baker, T. H., and D. W. Forbes	Hop- and Malt-drying.
„	2,904.	Mason, M. F., and G. Anderson	Bottling.
„	2,933.	Thompson, R. W., and C. Lampitt	Separator.
„	2,942.	Wood, J.	Malt-kiln Tiles.
„	2,964.	Brinsmead, H.	Screens.
„	3,049.	Cousins, C.	Screens.
„	3,107.	Buchholz, J. A. A.	Dressing Grain.
„	3,338.	Lessware, J. N.	Glucose.
„	3,481.	Allin, S. S.	Dressing Grain.
„	3,687.	Gill, F. N. G.	Adding Alcohol to Wort.

1875 (*continued*).

No.	3,744.	Catchpole, J. L.	Cleaning Grain.
,,	3,788.	Cooper, J.	Automatic Cask-tilt.
,,	3,855.	Wilson, J.	Mashing.
,,	3,929.	Lake, W. R. (from G. L. Squier)	Cleaning Grain.
,,	4,008.	Ashton, H.	Blending Taps.
,,	4,079.	Barlow, H. B. (from N. J. Galland)	Fermentation.
,,	4,111.	Hill, J.	Drawing Beer from Cask.
,,	4,218.	Demmer, B.	Malt-mill.
,,	4,224.	Rendle, R.	Bottling.
,,	4,274.	Broadbent, T., and D. Brown	Extracting Hops.
,,	4,328.	Thompson, J.	Mashing-gear.
,,	4,338.	Morgan - Brown, W. (from H. & G. Rose)	Cleaning Grain.
,,	4,465.	Childs, A. B.	Cleaning Grain.

1876.

No.	31.	Johns, T. H.	Raising Beer.
,,	50.	Franklin, A. C. F.	Cooling.
,,	143.	West, H. J. H.	Refrigerating.
,,	509.	Brodie, D.	Mashing.
,,	519.	Free, R. (from Pruvost-Volant & Fils)	Malt-kilns.
,,	586.	Wilson, T. E.	Drying Grain.
,,	612.	Haggett, W.	Malt-kiln.
,,	664.	Walker, A. B.	Heating, Cooling, Distilling; Condensing, Malting, and Saccharifying.
,,	901.	Gill, C. H. (from F. N. G. Gill)	Brewing.
,,	1,311.	Garton, W.	Brewing-materials.
,,	1,323.	Garton, W.	Brewing-materials.
,,	1,335.	Gillman, A. W., and S. Spencer	Bottling Beer.
,,	1,365.	Gibbons, R. A.	Making Casks.
,,	1,380.	Gibbs, W. A.	Drying Grain.
,,	1,483.	Bullough, W. H.	Lifting Beer, &c. from Barrels by Gas-pressure.
,,	1,684.	Smith, T. J. (from R. A. Heureuse)	Mashing.
,,	1,714.	Blake, A.	Treating Malt-grains.
,,	1,837.	Barotsley, J., and R. Hargreaves	Drawing from Casks.
,,	1,865.	Lloyd, A.	Preparation of Food and Drink.
,,	2,025.	Valentin, W. G.	Dextrine-maltose.
,,	2,162.	Massey, G., and H. Knott	Taps.
,,	2,260.	Clark, A. M.	Beer-taps.
,,	2,308.	Lyttle, W. A.	Drying Malt.
,,	2,380.	Firman, H. S.	Drying Malt, Hops, and Grains.
,,	2,405.	Wirth, F. (from Ritz, Brothers)	Malt-turner.
,,	2,825.	Barlow, H. B. (from N. G. Galland)	Pneumatic-malting.

1876 (*continued*).

No. 3,021.	Clark, A. M. (from G. Schock)	Cask-washer.
,, 3,076.	Simpson, R.	Brewing.
,, 3,151.	Forrest, A. and C.	Drying Grain.
,, 3,468.	Tasker, W. (from C. A. Duprez)	Cleansing Grain.
,, 3,521.	Boddington, H.	Brewing.
,, 3,713.	Lawrence, W.	Refrigerating.
,, 3,724.	Wirth, F. (from G. Ellenberger)	Grinding and Mashing.
,, 3,749.	Perry, A.	Malting and Drying.
,, 4,298.	Southby, A. G.	Automatic Mashing.
,, 4,301.	Johnson, J. H. (from H. Legru and G. Sencier)	Purifying Saccharines.
,, 4,317.	McDiarmid, F.	Casks and Taps.
,, 4,540.	Dewrance, J., and J. Mallinson	Cocks.
,, 4,552.	Brewer, E. G. (from Boulieu, Bros., and Charlon)	Drying Grain.
,, 4,632.	Scholes, E.	Steam-drying.
,, 4,649.	Nicholls, J. R.	Overflow-receiver in Fining.
,, 4,713.	Johnson, J. H. (from C. Völckner)	Malting.
,, 4,771.	Brook, L.	Beer-preservation.
,, 4,787.	Goodwin, A.	Drawing and Forcing Liquids.
,, 4,961.	Hoyne, J. F.	Drying Malt.
,, 4,979.	Shaw, T., and W. Blackburn	Measuring and Drawing Off Liquids.
,, 4,995.	Lake, W. R. (from O. F. Boomer and H. R. Randall)	Malt-syrup.
,, 5,056.	Sherwin, G. E.	Crushing and Grinding.

1877.

No. 80.	Garrett, N. D.	Making Yeast.
,, 381.	Clark, A. M. (from J. Guardiola)	Drying Grain, Malt, &c.
,, 404.	Simpson, U. S.	Vent-peg.
,, 437.	Nawrocki, G. W. (from K. Schultz)	Refrigerating.
,, 508.	Henley, T. F.	Saccharification.
,, 514.	Gardiner, W.	Testing Malt.
,, 567.	Bowing, J.	Filter-press.
,, 827.	Duvallon, G. and J. Csete	Refrigeration.
,, 850.	Pieper, C. (from L. Drevermann)	Filter-press.
,, 866.	Lascelles, C. T. E.	Store-vats.
,, 878.	Johnson, J. H. (from E. Kobosinski, and P. Landowski)	Malt Beverages.
,, 1,034.	Bell, H. and J., and J. J. Coleman	Refrigerating.

1877 (*continued*).

No. 1,044.	Pieper, C. (from J. P. Lipps)	Beer-cooler.
,, 1,150.	Carless, E.	Cask-filling.
,, 1,161.	Wise, W. L. (from J. A. Saladin)	Malting.
,, 1,183.	Lockwood, P. E.	Treating Malt-liquor.
,, 1,227.	Haddan, H. J. (from C. Pohl)	Cask-cleaning.
,, 1,233.	Perrins, H. H.	Hop-substitute.
,, 1,362.	McFadzean, C.	Elevating and Cleaning.
,, 1,968.	Clark, A. M. (from L. Chiozza)	Steeping Maize.
,, 2,391.	Barlow, H. B. (from J. Armengaud)	Malting.
,, 2,502.	Behnett, J. E.	Hop-press.
,, 2,726.	Liebert, J. A. (from S. A. Liebert)	Making Yeast.
,, 2,728.	Browne, A. (from L. Nicond)	Refrigerators.
,, 2,896.	Simmons, G.	Rousing.
,, 2,929.	Smith, J. T. (from R. A. Heureuse)	Mashing.
,, 3,020.	Sargeant, E.	Beer-tap.
,, 3,226.	Conradi, H. (from W. v. Sydow)	Mashing Maize.
,, 3,252.	Derbyshire, J.	Filter-presses.
,, 3,275.	Chapman, T. J., & J. G.	Bottling Beer.
,, 3,328.	Lake, W. R. (from L. Nemelka)	Roller Mill.
,, 3,332.	Burbidge	Preserving Beer.
,, 3,349.	Rohde, J. C. A.	Air-filter for Beer-pumps.
,, 3,378.	Tasker, J. W.	Cask-brush.
,, 3,398.	Roberts, G. C.	Refrigerating.
,, 3,474.	Maher, C.	Casks.
,, 3,478.	Dagnall, C.	Vent-pegs.
,, 3,548.	Brecknell, J.	Domestic Brewing-apparatus.
,, 3,589.	Lake, W. R. (from J. H. Brodie)	Grain-kiln and Gear.
,, 3,603.	Adams, G. A.	Registering-tap.
,, 3,607.	Knott, K.	Refrigerating.
,, 3,714.	Slater, J.	Casks.
,, 3,731.	Cressey, T. S.	Treating Malt.
,, 3,831.	Clark, A. M. (from A. Marbeau)	Malting.
,, 3,902.	McDonnell, A.	Bottling.
,, 3,931.	Swindells, J.	Cask-stand.
,, 3,950.	Garton, W.	Brewing-sugar.
,, 4,069.	Taylor, H. B.	Cask-tilter.
,, 4,106.	Searle, R.	Malt-kiln-ventilator.
,, 4,194.	Steel, J.	Coppers.
,, 4,269.	Stewart, A. and C.	Cocks and Taps.
,, 4,325.	Clarke, J. S.	Closing Empty Casks.
,, 4,364.	Lake, W. R. (from J. M. Galt)	Cleaning Grain.
,, 4,454.	Justice, P. S.	Tap.
,, 4,510.	Walker, A. B.	Brewing- and Distilling-plant.

1877 (*continued*).

No. 4,668.	Dangerfield, J.	Self-closing Tap.
„ 4,680.	Southby, E. R.	Mashing Maize.
„ 4,693.	Hancock, J. L.	Gas-aeration, &c., of Beers, &c.
„ 4,808.	Wilson, J. C.	Brewing.

1878.

No. 9.	Hildebrandt, J. A. R. (from E. Hahn)	Mechanical Malt-kilns.
„ 389.	Hodson, J.	Treating Hops and Beer.
„ 506.	Corréare, R. H.	Vessels for Distributing Liquids.
„ 580.	Lawrence, W. and G.	Refrigerator and Calorifiers.
„ 1,121.	Fenwick, J.	Brewing-vessels.
„ 1,122.	Siddeley, J., and F. N. Mackay	Attemperators.
„ 1,485.	Wirth, F. (from Marr and Co.)	Malting.
„ 1,722.	Higginbottom, J., and E. Hutchinson	Grinding.
„ 1,787.	Corrie, E. R.	Registering-taps.
„ 1,855.	Prager, M. M.	Making Yeast.
„ 2,043.	Freakley, W.	Filter-press.
„ 2,052.	Graham, C.	Fermentation.
„ 2,078.	Nawrocki, G. W. V. (from F. Littmann)	Attemperator.
„ 2,321.	Wirth, F. (from D. Gruber)	Malting.
„ 2,507.	Love, H.	Preserving Yeast.
„ 2,692.	Siddeley, J., and A. M. Dearn	Rousing.
„ 2,954.	Orchart, W., and R. Walpole	Receivers for Overflow from Fermenting Casks.
„ 3,085.	Harding, J.	Attemperator.
„ 3,135.	Neal, T.	Coffee-, Malt-, &c., Roaster.
„ 3,896.	Gretton, F.	Treating Hops in Brewing.
„ 4,028.	Hassall, A. H., and O. Hehner	Yeast.
„ 4,301.	Simon, H. (from G. Kühnemann)	Extracting Sugar and Proteins from Grain.
„ 4,420.	Copley, J. C.	Cask-cleaning Fluid.
„ 4,477.	Griffin, S., and T. A. Pearce	Skimming.
„ 4,533.	Nawrocki, G. W. V. (from F. Reichenkron)	Yeast.
„ 4,566.	Sorrell, W. H.	Rousing.
„ 4,668.	Clark, A.M. (from A.E. Feroe & J. Bennett)	Mashing.
„ 4,958.	Lake, W. R. (from C. W. Boynton)	Malt- and Grain- kilns.
„ 5,172.	Tasker. J. W. (from C. A. Duprez)	Malt-mill.

1879.

No. 255.	Wise, W. L. (from J. Dromel)	Brewing.

1879 (*continued*).

No.	320.	Holland, H. C.	Finings.
,,	422.	Yeadon, J.	Brewing-pans.
,,	531.	Tizard, P.	Malting.
,,	672.	Alexander, E. P. (from A. Millot)	Cleaning Grain.
,,	720.	Nawrocki, G. W. V. (from C. Scheidig)	Malting: Drying Grain.
,,	722.	Graham, C.	Yeast.
,,	808.	Reynolds, A. J.	Drying Hops.
,,	999.	Simon, H. (from N. Galland)	Malting.
,,	1,025.	Wirth, F. (from G. C. Holderer)	Brewing.
,,	1,051.	Farquhar, T. F. C., & W. Oldham	Fining.
,,	1,376.	Johnson, J. H. (from J. M. Dalton and C. Spittlehouse)	Refrigerating.
,,	1,398.	Wilson, H.	Attemperating.
,,	1,480.	Davidson, S. C.	Drying.
,,	1,537.	Reynolds, A. J. (from J. H. Reynolds)	Drying Hops.
,,	2,080.	Wise, W. L. (from F. Fanta)	Refrigerators.
,,	2,440.	Naumann, L., and C. Pöhl	Treating Hops.
,,	2,502.	Beanes, F. E. V.	Glucose.
,,	2,583.	Wirth, F. (from D. Gruber)	Malting.
,,	2,590.	Welz, E., and A. Rittner	Brewing.
,,	2,687.	Hoyne, J. F.	Drying Malt.
,,	2,834.	Kunkler, E.	Concentrating Beer, &c.
,,	2,866.	Clark, A. M. (from W. H. Allen)	Weighing Grain.
,,	2,970.	Coleman, J. J., and J. Bell	Cooling Air-supply.
,,	3,050.	Alexander, E. P. (from A. Millot)	Cleaning and Grinding Grain.
,,	3,104.	Siddeley, J., and A. M. Dearn	Drying Yeast and Hops.
,,	3,107.	Gillman, A. W., and S. Spencer	Casks.
,,	3,230.	Bruce, A. L., G. Stenhouse, W. McCowan and A. Haddon	Dextrine and Maltose.
,,	3,235.	Haddon, H. J. (from N. S. Hayes)	Drying and Curing Hops.
,,	3,305.	Collingridge, A., and H. R. Brett	Brewing-plant.
,,	3,481.	Manbré, A.	Starch-residues.
,,	3,573.	Rickaby, A. A.	Heating.
,,	3,588.	Abel, C. D. (from O. Braun)	Condensing, Cooling.
,,	3,706.	Handford, T. J.	Peptone, Yeast, &c.

1879 (*continued*).

No.	3,773.	McNulty, T. (from J. M. Dalton)	Refrigerating.
,,	3,780.	Bonser, A. E., and E.	Roasting.
,,	3,907.	Wilder, R. J.	Drawing and Blending.
,,	3,917.	Wilson, E.	Drying Grain.
,,	3,996.	Manbré, A.	Maize-starch Residues.
,,	4,014.	Alsing, G. V.	Filtering.
,,	4,035.	Wilson, H.	Malting.
,,	4,301.	Reynolds, A. J.	Drying Malt and Hops.
,,	4,307.	Brasier, E.	Cleaning Grain.
,,	4,372.	Prendergast, R., and R. Free	Malting.
,,	4,420.	Stopes, A. O.	Finings-machine.
,,	4,461.	Alsing, G. V.	Filter-press.
,,	4,584.	Ower, C.	Air-valve.
,,	4,685.	Stobbs, M., and G. Seagrave	Drying.
,,	4,848.	Tillman, F.	Mashing.
,,	4,910.	Engel, F. H. F.	Treating Beer.
,,	5,060.	Nunns, F.	Beer-engine.
,,	5,106.	Haig, H. V.	Yeast.
,,	5,171.	Allison, H. J. (from H. Mouchain)	Taps.
,,	5,219.	Fryer, A.	Drying-cylinders.
,,	5,274.	King, H. J. H.	Malt-kiln-heat-regulator.
,,	5,277.	Clark, A. M. (from W. H. Allen)	Weighing Grain.

1880.

No.	180.	Nutt, T.	Furnace for Copper.
,,	277.	Moss, C. A., and others	Steam-jacketted Pans.
,,	378.	Lake, W. R. (from W. C. de Sanford)	Refrigerating.
,,	512.	McGann, J.	Fermenting Glucose.
,,	516.	Vanderghote, A.	Saccharifying.
,,	655.	Collingridge, A., and R. F. Lecerf	Brewing.
,,	669.	Atkins, W.	Aerating Beer.
,,	682.	Cave, G. G.	Aerating, Attemperating, Blending.
,,	697.	Hoeking, F.	Refrigerating.
,,	704.	Daniel, H.	Concentrating Worts.
,,	1,068.	Schomburg, R.	Beer-fitter.
,,	1,083.	Schomburg, R. (from T. Remus)	Taps.
,,	1,444.	Barton, J.	Mashing, &c.
,,	1,471.	Gillman, A. W., and S. Spencer	Preserving Beer.
,,	1,867.	Palm, H. (from L. M. v. Markhoff)	Rotatory Malting.
,,	1,881.	Dugdale, E.	Brewing.
,,	1,967.	Wilson, J. C.	Boiling Worts.
,,	2,000.	Reynolds, A. J.	Drying Malt.
,,	2,061.	Lovett, W. J.	Gauge Tap.
,,	2,115.	O'Brien, G.	Brewing without Malting.
,,	2,245.	Johnson, J. H. (from W. Craig)	Mashing-gear.

1880 (*continued*).

No. 2,403.	Plunkett, J. R.	Roasted Maize.
,, 2,631.	Hodge, A. B., W. H. Hodge, and others	Electrolytic Purification of Saccharum.
,, 2,701.	Groth, L. A. (from C. Stahlschmidt)	Preserving Casks, &c.
,, 2,736.	Johnson, J. H. (from E. Porion and L. Mehay)	Treating Grains.
,, 2,914.	Neale, R.	Purifying Brewery-air.
,, 2,944.	Partridge, W.	Extraction-machine.
,, 3,020.	Wilson, J. G. (from P. Bahr & R. Brock)	Treating Maize.
,, 3,137.	Baxter, W. H.	Weighing-machine.
,, 3,170.	Neale, R.	Purifying Brewery-air.
,, 3,178.	Manbré, P. L.	Saccharifying Maize, Rice, &c.
,, 3,199.	Southby, E. R.	Treating Wheat, Rye, Rice, and Oats.
,, 3,214.	De Pass, E. (from Quiri et Cie.)	Malting.
,, 3,309.	Collingridge,, A. and R. F. Lecerf	Brewing.
,, 3,366.	Lake, W. R. (from T. A. Jebb and L. J. Bennett)	Maize-brewing.
,, 3,454.	Atkinson, J.	Steam-coils.
,, 3,469.	Currie, J.	Drying Grains.
,, 3,542.	Davidson, W.	Drying Grain.
,, 3,899.	Manbré, P. L.	Saccharifying.
,, 3,950.	Haddan, H. J. (from L. Janssens and E. Bodart)	Degerming Maize.
,, 3,969.	Steenberg, A. (from R. Jensen)	Germinator.
,, 3,975.	Fawcett, J. A.	Bran in Mashing.
,, 4,147.	Nicholls, A.	Float-gauge in Squares.
,, 4,385.	Dickenson, C., & J. W. Robson	Filtering Saccharum.
,, 4,403.	Cave, G. G.	Mashing.
,, 4,494.	Lake, W. R. (from C. W. Ramsay)	Preserving Beer.
,, 4,519.	Lake, W. R. (from C. W. Ramsay)	Ageing Liquors.
,, 4,615.	Jackel - Handwerck, H. H. W.	Cooling.
,, 4,617.	Walker	Portable Malt-kiln.
,, 4,751.	Southby, E. R.	Maize-brewing.
,, 4,780.	Wirth, F. (from L. Meller)	Aerating Beer in Cask.
,, 4,814.	Shears, J. C.	Sampling Wort.
,, 4,926.	Bloom, T.	Wort-copper.
,, 4,945.	Mills, B. J. B. (from H. Husack and A. Hanl)	Yeast-sluice.
,, 4,969.	Specht, A. (from K. W. Weissenborn)	Preserving and Drawing Beer.
,, 4,973.	Watson, D. McG., and A. C. Botterill	Blending Worts.

1880 (*continued*).

No. 5,061.	Bradford, W.	Blending Worts.
,, 5,402.	McEwen, J., and S. Spencer	Aerating Pump.
,, 5,451.	Brierley, W. (from A. Nohring)	Cooling.
,, 5,468.	Waller, R.	Brewery-lift.

1881.

No. 14.	Tenwick, J.	Portable Furnace.
,, 17.	Fulda, S.	Yeast.
,, 181.	Martin, J. H. C.	Husking Rice.
,, 197.	Lake, W. R. (from G. B. Boomer)	Drying Malt.
,, 205.	Rayner, T. G.	Refrigerator.
,, 344.	Gillman, A. W., and S. Spencer	Gelatinising Grain.
,, 458.	Manbré, A.	Saccharifying.
,, 477.	Dunlevie, T.	Beer-filter.
,, 509.	Tomkins, A. S., F. M. Courage, and F. A. Cracknall	Malt-kilns.
,, 611.	Davenport, W. W...	Steam-coils.
,, 747.	Defty, H.	Malt-kiln-stove.
,, 1,048.	Imray, J. (from A. P. Dubrunfaut)	Maltose.
,, 1,342.	Clinch, C.	Attemperating; Rousing.
,, 1,439.	Westwood, W. H., and E. T. Wright	Wort-valves.
,, 1,464.	Bonneville, H. A. (from A. Robert)..	Air-filter to Beer.
,, 1,468.	Worthington, A. B.	Barley and Glucose
,, 1,568.	Kincaid, G. W.	Roasted Malt.
,, 1,586.	Allender, G. M.	Arresting Fermentation by Phosphoric Acid.
,, 1,675.	Elliot, A. W., and C. van Outrive	Roasting Maize.
,, 1,716.	Storer, J.	Ammonia from Brewery Waste.
,, 1,742.	Mew, C. E. T.	Rotatory Malting.
,, 1,743.	Lake, W. R. (from E. Welz, & A. Rittner)	Clarifying: Exhausting Grains.
,, 1,886.	Cooper, A.	Blending Agitator.
,, 2,037.	Haddan, H. J. (from E. H. Potter)	Drying and Roasting.
,, 2,320.	Ewens, G. W.	Fining.
,, 2,377.	Digby, E. J. T.	Fining.
,, 2,448.	Martin, E., and R. Benns	Colour from Rice-malt.
,, 2,502.	Clark, A. M. (from H. Cutler)	Grain-drying.
,, 2,665.	Cooper, A.	Brewing-coppers.
,, 2,707.	Lake, W. R. (from C. W. Ramsay)	Ageing Beers.
,, 2,741.	Gough, A.	Colouring.
,, 2,798.	Bennett, J. A. B., and others	Raising Beer, &c.
,, 2,899.	Ullner, C. H. von ..	Syphon.

1881 (*continued*).

No.	3,025.	Andrew, C. H. (from E. H. Potter)	Drying Malt.
„	3,063.	Jensen, J. (from N. Rasmussen)	Yeast.
„	3,147.	Reynolds, A. J., & A. Q.	Malting.
„	3,149.	Randall, H. R.	Malt-extract.
„	3,314.	Muir, T.	Maize-brewing.
„	3,526.	Beck, W. H. (from J. C. A. Béliard)	Purifying Air and Gas.
„	3,660.	Morgan-Brown, W. (from C. H. & F. C. Hersey)	Drying Grain.
„	3,714.	Barrow, T.	Brewing.
„	3,725.	Cogswell, H. D.	Refrigerator.
„	3,881.	Luck, E.	Rousing: Gelatinisation.
„	4,163.	Salamon, A. G.	Treating Brewery Waste.
„	4,172.	Miller, F.	Rouser.
„	4,246.	Walker, A. (from J.)	Purifying Hops.
„	4,292.	Wood, A. E.	Salicylic Acid in Beer.
„	4,357.	Lake, W. R. (from C. Wahl)	Condensing Beer.
„	4,380.	Watson, J. (from A. Champy)	Malt-tester.
„	4,411.	Cave, G. G.	Mash-tun-strainer.
„	4,413.	Cave, G. G.	Wort-filter.
„	4,501.	Manbré, A.	Saccharifying.
„	4,699.	Apthorpe, W. H.	Mashing Maize, Rice, &c.
„	4,760.	Smith, P.	Yeast-skimmer.
„	4,857.	Lake, W. R. (from P. St. A. Basquin)	Drying.
„	4,890.	Salamon, A. G.	Filter-press.
„	4,891.	Fordred, J.	Roasting Grain.
„	4,959.	Higginbottom, J., & O. Stuart	Conveyors.
„	4,981.	Higginbottom, J., & O. Stuart	Grain-bins.
„	5,171.	Kinder, A.	Mash-tun.
„	5,560.	Brock, E. A.	Yeast.
„	5,739.	Kinder, T. B.	Maize-meal.

1882.

No.	5.	Groth, L. A. (from M. C. Seitz)	Mashing.
„	123.	Moreland, R.	Stillions.
„	271.	Haddan, H. J. (from P. Lefebvre, and J. Nagel)	Purifying Grain.
„	588.	Dell, W. B. and others	Cleaning Wheat.
„	802.	Morton, W., & P. Robinson	Refrigerator.
„	901.	Fraser, A. G.	Degerming Maize.
„	1,022.	Blythe, W.	Elevator.
„	1,088.	Inskipp, G., and J. McKenzie	Coppers.
„	1,188.	Walworth, J.	Drying Malt, &c.

1882 (*continued*).

No.	1,197.	Clark, A. M. (from G. D. Dennis)	Husking Rice, Wheat, &c.
,,	1,223.	Perry, A.	Malting.
,,	1,235.	Long, H., and H. Aplin	Rousing.
,,	1,428.	Free, R.	Steeping-cisterns.
,,	1,525.	Fisher, I.	Grain-drying.
,,	1,554.	Beanes, E.	Treating Grain.
,,	1,679.	Church, M. (from D. L. Shoemaker)	Cleaning Rice.
,,	1,909.	Dence, T., & J. J. Mason	Malt-extract.
,,	2,012.	Forbes, J., and J. Hamilton	Aerating Beer.
,,	2,014.	Armstrong, J. T.	Treating Rice, Maize, &c.
,,	2,076.	Mills, B. J. B. (from W. F. Howe)	Malting.
,,	2,214.	Korth, W.	Dressing Grain.
,,	2,372.	Webb, T.	Brewing-syrup from Dates.
,,	2,542.	Scholfield, Sir H.	Drying Grain.
,,	2,574.	Wetter, J. (from W. Ager)	Decorticating Grain.
,,	2,721.	Gillman, A. W., and S. Spencer	Mash-tun Strainer.
,,	2,995.	Moritz, E. R.	Brewing-solution.
,,	3,017.	Boult, A. J. (from L. Rappaport)	Cleaning and Grading.
,,	3,074.	Forster, W. G.	Treating Hops.
,,	3,117.	Wood, W., and W. Whitaker	Improving Beer.
,,	3,135.	Hoff, L.	Malt-extract.
,,	3,283.	Pitt, S. (from C. L. Gratiot)	Cleaning Wheat.
,,	3,407.	Martin, J. H. C.	Husking Rice.
,,	3,415.	Van Gelder, P.	Separator.
,,	3,552.	Lake, W. R. (from C. E. McNeal)	Separator.
,,	3,593.	Reddie, A. W. L. (from H. F. St. Requier)	Treating Grain.
,,	3,721.	Barraclough, A.	Boiling Beer.
,,	3,734.	Mansfield, L. E.	Conveyor.
,,	3,851.	Murray, G. W.	Dressing Grain.
,,	3,896.	Varicas, L. (from J. E. Gent)	Brewing.
,,	4,004.	Whitham, F. E.	Brewing.
,,	4,223.	Hone, G. J.	Elevator.
,,	4,244.	Capel, G. M.	Drying Grain.
,,	4,277.	Lawrence, W.	Brewing.
,,	4,335.	Russell, J. R.	Husking Rice.
,,	4,372.	Davidson, J., & others	Cleaning Grain.
,,	4,610.	Hamper, D. W., and E. Harper	Mashing-gear.
,,	4,611.	———, ———	Boiling.
,,	4,612.	———, ———	Finings.
,,	4,745.	Clark, A. M. (from G. E. and H. Cutler, and B. T. Thompson)	Grain Driers.
,,	4,808.	Vaux, C.	Cutting Finings.

1882 (*continued*).

No. 4,874.	Clark, A. M. (from G. Claudon, and C. Vigreux)	Yeast.
,, 5,294.	Blum, J.	Finings.
,, 5,308.	Lake, W. R. (from L. Gathmann)	Cleaning Grain.
,, 5,334.	Martin, J. H. C.	Husking Rice.
,, 5,429.	Dance, K. J.	Storing Grain.
,, 5,537.	Lake, W. R. (from F. W. Wiesebrock) ..	Grain-drying.
,, 5,618.	Lubbock, N. (from F. I. Scard)	Fermenting.
,, 5,643.	Biden, J. A. L., and W. V. Biden (from N. Pigeon)	Mashing-gear.
,, 5,655.	Boult, A. J. (from L. Smith)	Elevators.
,, 5,682.	Boby, R., & T. Stevens	Grain-screens.
,, 5,688.	Coleman, H. S., and others	Separators.
,, 5,869.	Armstrong, J.	Brewing.
,, 6,041.	Abel, C. D. (from L. M. von Markhof) ..	Malting.
,, 6,057.	Pitt, S. (from R. G. Starke)	Drying Malt.
,, 6,089.	Salamon, A. G.	Neutralising Beer, &c.

1883.

No. 110.	Allison, H. J. (from R. A. Messervey)	Refrigerator.
,, 250.	Haddan, H. J. (from W. Nussbeck)	Cooling Beer.
,, 257.	Alexander, E.P. (from P. Casamajor)	Filtering Saccharine.
,, 302.	Newton, H. E. (from J. Puvrez)	Brewing.
,, 456.	Norton, P. R	Malt-kilns.
,, 557.	Abel, C. D. (from L. M. v. Markhof) ..	Cleaning Grain.
,, 621.	Dean, R.	Fining and Filling Casks.
,, 731.	Johnson, J. H. (from E. Kokosinki, and E. Burnet)	Preparing Malt for Brewing.
,, 789.	De Pass, E. (from C. Golay)	Malting.
,, 907.	Abel, C. D. (from L. M. v. Markhof) ..	Steeping.
,, 930.	Welsh, W. I.	Taps.
,, 957.	Alexander, E. P. (from C. Zimmer) ..	Brewing.
,, 1,083.	Van Gelder, P.	Separator.
,, 1,123.	Harley, J. M.	Maize-starch.
,, 1,205.	Lawrence, W.	Brewing.
,, 1,389.	Dance, K. J.	Storing and Treating Grain.

1883 (*continued*).

No.	1,394.	Lake, H. H. (from F. Slama & F. Felix)	Treating Hops.
,,	1,433.	Peacock, T., and J. S. Sworder	Tap.
,,	1,458.	Adams, G. A.	Measuring out of Casks.
,,	1,510.	Stopes, H., and W. Crockford	Thermometer.
,,	1,550.	Bucknall, T., & W. S.	Brewing.
,,	1,693.	White, G.	Bunghole Cover.
,,	2,112.	Dixon, E. M.	Purifying Brewing-water.
,,	2,134.	Lund, R., & T. F. Hind	Dressing Grain.
,,	2,502.	Powell, R.	Sulphite of Lime.
,,	2,660.	Björling, P. R.	Brewing-pans.
,,	2,663.	Shield, H., and W. N. Crockett	Separator.
,,	2,703.	Polson, J., and J. M. Harley	Starch.
,,	2,714.	Jackson, J. P.	Lager Beer.
,,	2,837.	Haddan, H. J. (from W. H. Uhland and V. Machovsky)	Pressed Yeast.
,,	2,840.	Gatward, J. H.	Separators.
,,	3,100.	Cleary, M.	Cooling.
,,	3,129.	Edwards, E. (from J. Beumier)	Malt-kilns.
,,	3,321.	Wirth, F. (from A. Reihlen)	Fermenting.
,,	3,368.	Cadle, C., and J. T. La Du	Separator.
,,	3,397.	Lake, H. H. (from H. A. Hughes)	Clarifying Saccharine.
,,	3,436.	Dawson, W. E. T.	Vent-peg.
,,	3,547.	Trenery, H. C., and J. Naylor	Drawing from Casks.
,,	3,714.	Dackus, W. A., & W. S.	Tapping Casks.
,,	3,831.	Clark, W. (from A. E. Feroe, W. E. Feroe, and J. S. Bancroft)	Beer, &c.
,,	3,928.	Linden, W. P.	Treating Hops.
,,	4,053.	Thompson, W. P. (from G. Pommer, and P. P. Ebell)	Regulating Fermentation.
,,	4,182.	Walker, J., and A. Howell	Tapping.
,,	4,251.	Moiske, B.	Glucose.
,,	4,343.	Elsworth, R. C.	Vent-pegs.
,,	4,374.	Ritchie, J.	Cleaning Grain.
,,	4,387.	Haddan, H. J. (from C. Coster)	Glucose.
,,	4,408.	Redfern, G. F. (from F. Slama & F. Felix)	Treating Hops.
,,	4,434.	Derham, T.	Hydrometers and Saccharometers.
,,	4,449.	Watt, J.	Malt-kiln.
,,	4,532.	Bell, R. G.	Preserving Beer.
,,	4,757.	Briggs, S.	Refrigerators.

1883 (*continued*).

No.	4,948.	Engel, F. H. F. (from M. E. Meyer)	Pneumatic Malting.
,,	5,044.	Boult, A. J. (from C. Lauer)	Raising Beer by Gas.
,,	5,046.	Boult, A. J. (from J. P. Schönig)	Vent-peg.
,,	5,053.	Poehl, O. E.	Preserving Beer.
,,	5,126.	Lake, H. H. (from H. Kunheim, and W. Raydt)	Clarifying Beer.
,,	5,197.	Haddan, H. J. (from L. Bandeville)	Cleaning Grain.
,,	5,444.	Haddan, H. J. (from O. Coldewe, and L. Schönjahn)	Germinator.
,,	5,463.	Birch, E., and P. J. Catterall	Heating Beer.
,,	5,614.	Aubert, W.	Preserving Beer.
,,	5,694.	Wirth, F. (from G. Stein)	Screening Green-malt.
,,	5,801.	Anderson, J. (from Lyall, Gray, & Co.)	Cleaning Grain.
,,	5,805.	Bradley, N.	Yeast.
,,	5,890.	Fordred, J.	Torrefying Grain.
,,	5,891.	Fordred, J.	Dried Yeast.
,,	5,963.	Sombart, C. M. (from B. Möbius)	Refrigerator.

1884.

No.	639.	Herbert, W. G.	Grain-elevators.
,,	764	Southby, E. R.	Cleansing Beer.
,,	766.	Milne, J.	Drying Grain.
,,	1,269.	Southby, E. R.	Treating Grain for Brewing.
,,	1,401.	Bonne, C. R.	Straining Yeast.
,,	1,413.	Haddan, H. J. (from C. Jaquet)	Elevator Cups.
,,	1,536.	Bonne, C. R.	Purifying Yeast.
,,	1,916.	Arkcoll, C.	Preparing Wort.
,,	2,069.	Colton, E. G. (from V. Wilhelmi)	Cooling.
,,	2,468.	Haddan, H. J. (from H. Hackmann)	Malting.
,,	2,564.	Colton, E. G. (from L. Herrmann)	Malt-drying.
,,	2,694.	Uhlhorn, D., jun.	Husking Grain.
,,	2,874.	Black, J.	Drying Grain.
,,	3,119.	Dunlop, R.	Casks, &c.
,,	3,843.	Read, W. T.	Preserving Beer.
,,	3,861.	Lyster, G. F., and A. G. Lyster	Elevators.
,,	4,114.	Ritchie, J.	Cleaning Grain.
,,	4,182.	Pemberton, E. T.	Brewing.
,,	4,350.	Mewburn, J. C. (from C. F. L. Frohberg)	Separating Green-malt.
,,	4,473.	Bell, R. G.	Preserving Beer.

1884 (*continued*).

No. 4,563.	Dufrené, H. A. (from N. Duboc-Barilly)	Cooling Beer.
,, 4,640.	Crickmer, F. W.	Mash-tun Strainers.
,, 4,690.	Hocking, H.	Cooling.
,, 4,945.	McFarlane, J.	Mashing-gear.
,, 5,104.	Cooke, J.	Wheat-washer.
,, 5,234.	Barrell, L. J.	Corn-screen.
,, 5,299.	Stephens, H.	Cooling.
,, 5,372.	Wirth, F. (from G. Stein)	Separating Green-malt.
,, 5,445.	Lobb, H. W.	Purifying Beer, &c.
,, 5,725.	Haddan, H. J. (from B. Gervais)	Brewing-plant.
,, 5,745.	Bauermeister, E. L. H.	Husking Grain.
,, 5,746.	Plönnis, R. F. L.	Drying Grain.
,, 5,747.	Aubert, W., jun.	Aerating Beer.
,, 5,883.	Briggs, S.	Refrigerators.
,, 5,903.	Starkey, T. & G. Clapp	Mashing-gear.
,, 6,047.	Aplin, H.	Coppers.
,, 6,259.	Powell, G. F.	Making Yeast.
,, 6,393.	Abel, C. D. (from C. Zimmer)	Brewing-plant.
,, 6,620.	Seney, H.	Preparing Malt.
,, 6,728.	Alexander, E. P. (from N. Galland)	Malting.
,, 6,830.	Drechsler, F. J.	Separator.
,, 7,019.	Maitland, A.	Making Yeast.
,, 7,209.	Greig, J.	Drying Hops, Grain, &c.
,, 7,215.	Kiefer, G.	Grain Cleaning.
,, 7,398.	Stidolph, T. F.	Separator.
,, 7,471.	Evans, P.	Elevator.
,, 7,810.	Wills, W. H.	Cooling.
,, 7,850.	Page, E., & R. Ranger	Mixing Lengths.
,, 7,922.	Heathorn, G. J.	Purifying Musty Beer.
,, 7,967.	Gossi, M.	Treating Grain.
,, 7,981.	Schnell, A.	Treating Grain.
,, 8,097.	Johnson, J. H. (from M. Marolle)	Conveyors.
,, 8,171.	Johnston, J. W.	Cooling Gear.
,, 8,321.	Stanton, W. S.	Cleaning Grain.
,, 8,717.	Bonne, C. R.	Making Yeast.
,, 8,742.	Houssart, C. V.	Mashing.
,, 8,898.	Goodfellow, A. J.	Malthouse-floors.
,, 9,011.	Flinn, J.	Malting.
,, 9,546.	Brewer, E. G. (from L. Koppel)	Ventilating Maltings.
,, 9,804.	Corbett, T.	Dressing Grain.
,, 9,871.	Graham, C.	Treating Bottled Beer.
,, 10,044.	Hocking, H.	Cooling.
,, 10,102.	Rainforth, W., sen. and jun., and H. S. Rainforth	Corn-screen.
,, 10,109.	How, W. A.	Aerating Beer.
,, 10,422.	Gale, J., & R. Liddle	Brewing.
,, 10,427.	Shrivell, F. W. E.	Hop-substitute.
,, 10,437.	Groth, L. A. (from E. Luhmann)	Aerating Beer.

1884 (*continued*).

No. 10,440.	Groth, L. A. (from J. A. Gfall)	Preserving Hops.
,, 10,686.	Clark, A. M. (from E. L. J. Boniface)....	Fermenting Lævulose.
,, 10,775.	Parkinson, G. M., and J. G. Walker	Heating Grain.
,, 10,947.	Worssam, H. J.	Coppers.
,, 11,259.	Hocking, H.........	Cooling.
,, 11,326.	Duckham, F. E.	Conveyors.
,, 11,863.	Chapman, G. E.	Corn-riddle.
,, 12,002.	Ley, F.	Elevator.
,, 12,136.	Haddan, H. J. (from P. Schaar)	Cellarage.
,, 12,143.	Harris, B. P., and A. Stage	Kiln-floors.
,, 12,414.	West, T.	Decorticating Rice, &c.
,, 12,540.	Spence, W. H. (from L. J. Charpentier)	Cleaning Grain.
,, 12,570.	Craig, J.	Decorticating Wheat.
,, 12,584.	Pearson, P. W......	Worm-conveyor.
,, 12,695.	Bone, W.	Cleaning Barley, &c.
,, 12,627.	Worssam, H. J......	Conveyors.
,, 12,940.	Robertson, M.......	Malt-ploughs.
,, 12,977.	Worssam, H. J.	Hop-press.
,, 13,186.	Harris, B. P.	Hop-washing.
,, 13,749.	Capell, G. M.	Elevator.
,, 13,800.	Hope, W. and G. F. Deacon	Drying Grain.
,, 13,806.	Pontifex, F.........	Perforated False-bottoms.
,, 14,011.	Imray, J. (from L. Cuisinier)........	Saccharifying.
,, 14,211.	McRory, S. M.......	Dressing Grain.
,, 14,694.	Horsburgh, T.......	Preparing Finings.
,, 14,727.	Inglis, T.	Cleaning Grain.
,, 15,265.	Jago, W.	Controlling Heat in Fermentation.
,, 15,274.	Rowlandson, W.....	Cleaning Wheat.
,, 15,494.	Rowlandson, W.....	Cleaning Wheat.
,, 15,852.	Haddan, H. J. (from W. Lawrence)....	Drying Malt.
,, 15,874.	Hewitt, T. W. G. ..	Beer-extractor.
,, 16,047.	Blackledge, J.......	Cleaning Grain.
,, 16,205.	Woodall	Elevator.
,, 16,500.	Clayton, J.	Metal-separator.
,, 16,598.	Edwards, W. C.	Skimming.
,, 16,605.	Jago, W.	Wheat-testing.
,, 16,868.	Levinstein, L.	Aerating Beer.

1885.

No. 46.	Platt, P., and J. M. Aitchison	Malt-kilns.
,, 58.	Manbré, A.	Brewing.
,, 127.	Briggs, S...........	Refrigerator.
,, 211.	Gillman, A. W., and S. Spencer	Gelatinising Grain.
,, 528.	Evans, P.	Cleaning Grain.

1885 (*continued*).

No.	529.	Bennett, S.	Preserving Beer.
,,	868.	Agar, H.	Vent-peg.
,,	925.	Robson, J. J.	Cleaning Malt.
,,	1,032.	Death, J.	Gelatinising Grain.
,,	1,046.	Ramsden, W. T.	Backs.
,,	1,124.	Perry, A., and J. V. Walmesley	Roasting Grain.
,,	1,261.	Powell, B.	Straining Beer.
,,	1,417.	Gatward, J.	Separator.
,,	1,656.	Belling, G. F.	Automatic Vent-peg.
,,	2,037.	Pontifex, F.	Cask-washer.
,,	2,072.	Johnson, J. H. (from H. Graepel)	Separator.
,,	2,078.	Beck, W. H. (from M. Marcus)	Heading.
,,	2,111.	Davis, T. J. E.	Tapping Casks.
,,	2,132.	Rainforth, H. S., W. Rainforth, & others	Grain-screens.
,,	2,137.	Lake, W. R. (from A. Lenormand)	Cleaning Grain.
,,	2,208.	Lake, W. R. (from F. W. Wiesebrock)	Using Grains.
,,	2,273.	Hammond, J.	Vent-peg.
,,	2,717.	Woodward, —. (from C. Ward)	Cask-filling.
,,	2,748.	Death, J.	Drying Gelatinised Grain.
,,	2,980.	Sinclair, R. C.	Turning Malt on Kiln.
,,	3,147.	Dawson, G. A.	Cleaning Grain.
,,	3,167.	Hind, G.	Elevator.
,,	3,193.	Behr, A.	Malting.
,,	3,208.	Gent, J. F.	Treating Rice.
,,	3,217.	Rollason, R.	Automatic Cask-tilt.
,,	3,577.	Imray, J. (from M. Hatschek)	Pressed Yeast.
,,	3,658.	Attwood, A.	Bushes.
,,	3,752.	Death, J.	Cask-enamel.
,,	3,768.	Clayton, J.	Raising Beer.
,,	3,800.	Lampitt, C.	Cleaning Grain.
,,	3,815.	Greig, G.	Drying Grain.
,,	3,877.	Long, H.	Skimming.
,,	3,955.	Jenkinson, M.	Corn-screen.
,,	3,973.	Reynolds, R.	Broken-grain-separator.
,,	4,043.	Keighley, E.	Drying and Cleaning Grain.
,,	4,068.	Lawrence, W.	Treating Malt.
,,	4,233.	Tomlinson, C., and J. Porter	Grader.
,,	4,306.	Beaven, S.	Separator.
,,	4,336.	Tenwick, J.	Automatic Bunghole-closer.
,,	4,349.	Corrigan, J.	Tapping and Venting.
,,	4,524.	Death, J.	Preparing Grain.
,,	4,525.	Death, J.	Cask-enamel.
,,	4,526.	Death, J.	Cask-enamel.
,,	4,703.	McKinless, J.	Bunghole-cover.
,,	4,866.	Shield, H., and W. N. Crockett	Corn-screens.

1885 (*continued*).

No. 4,956.	Lake, W. R. (from W. T. Jebb)	Brewing.
„ 4,957.	Lake, W. R. (from W. T. Jebb)	Treating Maize.
„ 4,980.	Scothern, S.	Cask-tilt.
„ 4,988.	Haddan, H. J. (from P. Lauth)	Drying Malt.
„ 5,032.	Britten, H. E.	Malt-kiln.
„ 5,096.	Holgate, J., and J. B. Holgate	Worm-conveyor.
„ 5,439.	Abel, C. D. (from C. Meyer)	Stopping Fret.
„ 5,647.	Barker, G.	Aerating.
„ 5,749.	Gough, J. T.	Germinating Floors.
„ 5,750.	Gough, J. T.	Drying Malt.
„ 5,882.	Boake, A., and F. G. A. Roberts	Potassic Sulphite.
„ 5,883.	Boake, A., and F. G. A. Roberts	Brewing.
„ 6,060.	Redfern, G. F. (from L. Pinet)	Separator.
„ 6,072.	Swonnell, A.	Finings.
„ 6,243.	Mewburn, J. C. (from G. Noback and W. Gintl)	Treating Brewery-waste.
„ 6,287.	Everard, J.	Automatic Vent-peg.
„ 6,288.	Squire, W. S.	Yeast.
„ 6,493.	Milne, J.	Drying Malt.
„ 6,589.	Faulder, H.	Roasting Malt.
„ 6,647.	Radford, W. H.	Malt-screen.
„ 6,804.	Sinclair, R. C., and J. Hodson	Turning Malt on Kiln.
, 6,948.	Burch, J., & W. J. Hall	Cask-taps.
„ 7,032.	Day, C. A. (from W. A. Cockrell)	Cleaning Grain.
„ 7,185.	Bishop, A. S., & F. Down	Cask-stand.
„ 7,378.	Salamon, A. G.	Treating Brewery-waste.
„ 7,736.	Canty, T. J.	Mash-tun Coils.
„ 7,788.	Cuisinier, L.	Preserving Saccharum.
„ 7,826.	Hinde, T. P.	Gas-boiling.
„ 8,115.	Holgate, J., and J. B. Holgate	Grader.
„ 8,176.	Haddan, H. J. (from E. Fritsch)	Cleaning Grain.
„ 8,333.	Lake, W. R. (from W. A. Cockrell)	Cleaning Grain.
„ 8,424.	Downing, G. (from F. J. Sommer)	Cleaning Malt.
„ 8,432.	Rowat, R.	Rice-screen.
„ 8,563.	Rhoden, S.	Mash-tuns.
„ 8,652.	Redfern, G. F. (from C. Völckner)	Maltings.
„ 8,908.	Peters, J. J. W.	Yeast.
„ 9,024.	Alexander, E. P. (from A. Millot)	Cleaning Grain.
„ 9,207.	Challender, J.	Aerating.

1885 (*continued*).

No. 9,549.	Payne, E., & E. L. Sheldon	Vent-peg.
,, 9,559.	Mills, B. J. B. (from A. J. Reynolds)	Malt-stirrer.
,, 9,574.	Engelberg, E. C.	Husking Rice.
,, 9,683.	Williamson, W. H.	Separator.
,, 9,750.	Wilkes, J.	Bunghole Cover.
,, 9,792.	Hughes, A. T.	Vent-peg.
,, 9,798.	Boult, A. J. (from A. S. Bigelow)	Pressure-regulator.
,, 9,813.	Engrand, C.	Bins.
,, 9,847.	Justice, P. M. (from A. W. Billings)	Brewing.
,, 9,950.	Lake, H. H. (from A. E. Fewe)	Maize Brewing.
,, 9,956.	Bonne, C. R.	Malt-testing.
,, 10,077.	Johnson, J. A., and W. B. Johnson	Bins.
,, 10,142.	Cockcroft, H., & F. Spong	Vent-peg.
,, 10,168.	Sharratt, F. A.	Vent-peg.
,, 10,358.	Hedicke, M.	Drying Malt.
,, 10,527.	Warne, H. J.	Refrigerators.
,, 10,853.	Scholes, E.	Cleaning Grain.
,, 10,949.	Fielding, E.	Cooler-valves.
,, 11,070.	Morton, R. G.	Conveyor.

APPENDIX.

Papers upon Repeal of Duty, read before the British Association in 1881 and 1882.
Tables of Quantities of Malt Made and Prices of Barley, 1781—1880.
Malt Duty Paid, Men Employed, and Quantities Made, 1858—1882.
Barley Sales and Prices Realised, 1879—1882.
Average Production of Barley in Great Britain.
Licence Statistics, 1883.
Record Sheets (Heats).

A BOOK on Malting would be incomplete without reference to the laws which, at one time, and for so long, fettered every act connected with the trade. Seven generations of maltsters were born, flourished, and passed away under a legal surveillance that was as bad in its influence on improvement in malting as Turkish rule has proved to the Fellaheen of Egypt. A brief outline of the history of the Malt Tax is a necessity. It has been already given by me, pp. 8—18. It may remind the liberated maltsters of the future that they are free, and that their escape from thraldom involves the responsibility of progress. Happily the trade is now absolutely free, and it is to be fervently desired it may ever remain so. No longer have men to work to order. Formerly they were tied to enter all corn steeped, the hours of steeping, the shape, size, and position of cisterns, couch frame, floors and kilns. All these were fixed by a long succession of laws, that must have weighed heavily upon the spirits of maltsters, and certainly hung a dead weight upon improvement in malting, making experiment at all times difficult and frequently impossible. It seems already almost incredible that so much ingenuity could be exercised in so simple a craft that 101 penalties* could be attached to fraudulent intent, and to oversight, innocent or otherwise.

SOME RESULTS OF THE REMOVAL OF THE MALT TAX.†

Landowners, farmers, brewers, maltsters, and merchants are directly interested in watching the results of the removal of one of our most venerable taxes. It is sufficiently important to claim at least the passing attention of the public generally, and of this section in particular. I need scarcely remark that

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[*] See 7 and 8 Geo. IV. cap. 52.

[†] By H. STOPES. Read at York before the British Association, 1881.

this question is a very wide one, and that I shall attempt to look at a few only of its more important points.

A brief outline of the history of the old malt tax may place it before this section * in a light that will enable some of the present and possible future results to be generally understood and more accurately estimated.

Malt, in common with almost every other article of general utility, has occasioned an enormous amount of legislation. Prior to the imposition of the tax it did not occupy very much attention, although some Acts regulating its manufacture were passed in many reigns, from Richard II. to William III. Stow mentions some restrictions placed upon maltsters as early as Edward II., 9th (1315). Popularly the Malt Tax is supposed to have originated in 1697. As, however, it existed in a variety of forms, but always in the shape of a tax, this is simply a common fallacy. The tax appeared for the first time in 1644, when money was so much needed to carry on the civil war then raging. It was enacted that a duty of 2s. per quarter should be levied upon all malt made from wheat and barley, and 1s. 4d. on that from oats. At this time, also, private brewers were made to pay a tax of 12½ and common brewers 25 per cent. of the value of the beer made by them. This shows that the Government of two hundred and forty years ago placed private and common brewers upon a different basis of taxation, and furnishes a very venerable precedent for the system so very recently adopted (of which I have more to say later on). In 1697 a tax of 6d. per bushel was imposed by William III. Until September 30, 1880, this was collected constantly and uninterruptedly, varying only in amount. For upwards of sixty years it remained at 6d. per bushel; only, in 1804 to 1816 it experienced the grievous charge of 4s. 5¾d. per bushel. The attempts to introduce this tax into Scotland were for a long time unsuccessful. The Scottish Parliament tried it in 1695 unavailingly, and in 1713 (after the Union) the Imperial Parliament repeated the attempt, but such decided opposition was offered by all classes, that it seriously threatened the stability of the union of the two countries. Peers and members of both Houses worked very hard to prevent the Act passing, the Earl of Findlater even going so far as to move for leave to bring in a bill to dissolve the Union. Maltsters everywhere positively refused to be surveyed, and if the officers of Excise tried to compel them by law, not a single Justice of the Peace could be found in any county who would act against them or enforce the law. For years this continued, so that in 1725 the amount realised in all Scotland by the tax was under £12. When the Government determined to enforce its payment generally, very serious rioting took place. Two companies of infantry sent to Glasgow were driven to Dumbarton with much loss, and great damage to property took place.

It would be a long and tedious process to wade through, however quickly and briefly, the innumerable regulations and

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* Economics and Statistics.

restrictions of the numerous Acts of Parliament that appeared almost annually for nearly two centuries. Farmers, maltsters, and brewers all complained of them. Efforts of every kind were made to abolish the tax altogether, or place it upon the beer or wort produced, so as to leave the farmers free. Few individual things may claim to have occupied so much attention, or raised more discussion in the past. Few things have proved so restrictive in operation, or so direct an incubus upon a number of industries.

Leaving the historical part, let us now glance at the opinions recently expressed by the acknowledged representatives of the great body of men who are, and necessarily must be, the most directly interested in the question, viz., the farmers and landowners. In 1870, and again in 1871, deputations from the Central Chamber of Agriculture waited on the Chancellor of the Exchequer, and urged upon him the desirability of repealing the Malt Tax for a number of reasons, among which were the following:—

I. Because it acts as a fine upon high farming.

II. Because farmers are not able to use malt for food for live stock, the Malt-for-Animals' Act being inoperative by reason of its expense.

III. Because the tax interferes with the most remunerative rotation of crops, and limits the growth of barley.

IV. Because it does not pay to grow inferior kinds of barley.

V. Because the British farmer is unable to compete with foreign farmers, who can use germinated grain without payment of duty.

VI. Because with the Malt Tax repealed the labouring classes would be able to brew their own beer.

I. Now, if the tax acted as a fine upon high farming, then the first decided result of its repeal is to remove a distinct premium which the former method of assessment gave upon high-class fine barley. This is easily explained. All barley made into malt paid (until the end of September last) the same amount of duty. If it was of fine quality, it paid no more duty than other barley of an inferior kind. A brewer, therefore, using malt made from a superior barley, paid only the same duty, bulk for bulk, as another brewer using either badly made malt or malt made from bad barley. This, as a consequence, virtually formed a premium upon all superior barleys, as, apart from the other advantages to a skilled brewer of using such barley, there was a direct pecuniary gain of sometimes over 15 per cent. of the duty paid above the average malt, the average extract estimated by the Commissioners of Excise being taken at 82 lbs. (by Long's saccharometer). When rightly used, superfine malts yield 95 lbs. or more extract, or 13 lbs. over the average. This additional yield more than compensated for the extra first cost of such barley as was needed to make the malt, consequently the gain of 15·8 per cent. upon the duty paid as a direct pecuniary encouragement to all brewers who had sufficiently keen perception to detect the difference, and they willingly paid for better barley 4s. and upwards per quarter more than they were actually worth, apart from the duty. This perfectly just and healthful stimulus to farmers and brewers is now swept away, and a portion of the loss falls upon the farmers and owners of the land, who invariably shared the benefit with the brewers, but more especially in years of short and defective supplies. By the present beer tax, also, an increased charge is made upon all well-made malt from fine barley, as the extra value of the material gives a greater product, and the product is charged instead of the material, *i.e.*, a quarter of fine malt, yielding 95 lbs. extract, makes four and a half barrels of beer, and pays 28s. duty, whilst ordinary malt makes four barrels and pays 25s. duty approximately.

II. "Because farmers are not able to use malt for food for live stock." This objection raises the question as to the real benefit of malt and germinating grain to the farmer. At present we do not find much malt being used for feeding purposes. Both elaborate experiment and direct experience have taught that malt is of little greater value as food than barley, excepting in small quantities as a condiment, or for occasional use. To support this statement I refer those interested in the inquiry to the Parliamentary Report of 1866 upon the experiments of Messrs. J. B. Lawes and H. Morris, and also to the fact that when liberty was given to make malt for feeding purposes mixed with a certain proportion of linseed meal (so as to render it unfit for brewing purposes) the first year twenty-eight maltsters made nearly 8,750 qrs. of such malt, and within five years not one maltster remained manufacturing it, nor since 1870 has one quarter of such malt been made.

III. "The tax interferes with the most remunerative rotation of the crops, and limits the growth of barley." Instead of this being the case, farmers have found that barley has paid better than wheat, and throughout almost the whole of Great Britain, but especially in some favourable districts, the breadth of barley has very considerably increased of late years. Farmers may, eventually, not simply arrive at the conclusion that every 100 qrs. of maize and rice made into beer means so many qrs. of barley unused, but the truth may dawn upon them that 100 qrs. of maize and rice equals in product 120 qrs. barley, or more.

IV. "Because it does not pay to grow inferior kinds of barley." If that were the case in the past farmers already find from a single season's experience that the present beer tax makes inferior barleys of less value than before, for the double reason, that it will now pay to malt many kinds of foreign barley that were before unfairly hampered by the duty, and that whereas a brewer has hitherto been compelled to use either malt or sugar, he is now at liberty to use any material he chooses, and as sugar is dearer to a brewer than grain, large quantities of maize, rice, &c., are used that necessarily displace British barley. Hence, demand is diminished, price must decline also, or supply must fall off.

V. "Because the British farmer is unable to compete with foreign farmers, who can use germinated grain without payment of duty." An Act was passed (33 & 34 Vic. c. 32, 56) which gave farmers liberty to steep and grow grain with very little interference from the Excise; but such saccharised grain is so little used that in many counties it is still absolutely unknown, and throughout the country the way in which farmers neglect to give malt to their cattle offers rather conclusive evidence as to the real purpose for which they wished cheaper malt.

VI. "Because with the Malt Tax repealed the labouring classes would be able to brew their own beer." This last objection should be first and greatest. This concession alone contains the only pecuniary benefit to the farming and labouring classes. Now farmers are able to give their men malt in the place of wages, or else much more beer at less cost than hitherto. Many now give less money for beer, or only the same quantity of malt and hops as before. Then three bushels malt and three pounds hops cost 31s. 6d., now they cost 18s. Labourers and poor people generally are apparently able to brew beer for themselves at much less cost than they could in the past by honest means, or than at present they are able to buy it of common brewers; for before it can be sold it must pay to the Chancellor of the Exchequer the sum of 6s. 3d. for every barrel of standard gravity—a specific gravity of 1057.

As a fact, this apparent boon to the labouring classes really amounts to a national waste. Farmers and labourers do not know how to brew. Even if they had the knowledge, they have not the necessary plant—hence much material is wasted at the outset; it is simply impossible for them to secure a good extract. During the after processes of fermentation and storing, much is spoiled and rendered unfit for drinking; consequently, an ordinary brewer of average knowledge and intelligence, provided with a properly arranged plant and appliances, can produce from 100 quarters of malt, not only more beer of uniform quality and goodness, but can sell it at a profit after paying from 25s. to 27s. per quarter duty.

As to the wisdom and justice of allowing the poorest section of the community the liberty of obtaining intoxicating and wretchedly-made beverages at four-fifths the cost price to other people, I have nothing to say, but if it is right to let farm labourers in England make their own beer duty free, entirely as they please, it would be only common justice to allow other farm labourers in Scotland and Ireland, who do not drink beer, to distil whiskey from their malt if they prefer it. Seeing that malt is now only of the same value as barley—bulk for bulk—and can be made by any one without question, the temptation to practise illicit distillation is greater than formerly. The great mass of the people are made to pay more for their beer to enable a small and already too "beery" section to get theirs at less than market price.

Setting aside all these objections, farmers will find the repeal of the Malt Tax act more against their interests, because barley is no longer subject to a monopoly. The former mode of collecting the tax practically shut out foreign barleys from the mash-tuns of the vast majority of brewers. Few but the largest brewers cared for the expensive best barleys of Germany and France. Only a very few were sufficiently acquainted with the value of the thin Chilian, Algerian, or Egyptian barleys. All were compelled by law to use malt or sugar, as the natural laws of fermentation, or, in other words, sustenance of the yeast cells, made it impossible to most brewers to use more than a certain percentage of sugar, usually a small one, and the rest malt. Now all this is changed—the monopoly has ceased to exist. A brewer can brew in a way better in every sense, by using a proportion of other grain than malted barley. Hence, if a large proportion of the barley of this present harvest were destroyed, we should not see prices nearly so high as two years ago they would have been if one-tenth only of the mischief had been done. Now, too, it is very probable that large quantities of malt made abroad will be imported into this country. The result of all these causes combined must effect a heavy loss to British land-owners and farmers.

Maltsters, as a body, will in some ways lose as much as farmers. Formerly a maltster derived a good portion of his profit from skilful manipulation of the duty. This is now entirely lost to him. The competition of raw grain may prove more fatal to his interest than to the classes already mentioned. The loss, however, will fall only upon the men of one idea, who persist in working as their fathers did before them for many generations. If the change is bad for maltsters it is exceedingly good for malting. They need not complain. Now there is an opportunity given for improvement, and the rude, primitive, and unscientific modes of working in many even of the largest and most costly of the maltings now at work, will have to make way for the enlightened teachings of science. Those maltsters who have enough intelligence to make their trade a scientific pursuit will add to the wealth of the nation and enrich themselves. Malt will, and must, be vastly improved in manufacture and value. The malting process will get to be recognised as the most important of the first steps in the production of sound, pure beers. Illiterate and ill-trained maltsters are being swept away.

To brewers the change is of less importance than it would appear at first sight. The actual charge upon each quarter of malt now used by the very great majority of brewers exceeds the former duty. Then a quarter paid 22s. 8d., inclusive of brewer's license. Now each quarter is assumed to yield 82 lbs. gravity, and has to pay 25s., less 6 per cent.; but as in most breweries (and all good ones) the yield of the malt is more than 6 per cent. greater than 82 lbs., it is fairly within bounds to assume that each quarter of malt now yields to the revenue 25s., an increased charge of 2s. 4d. This money is of course paid by the general public. The increase does not add the large amount to the national revenue that it should do, as every quarter used by private brewers paying the 6s. licence only, in excess of the first quarter used, pays no duty.

A large amount of beer now brewed entirely escapes taxation. The power to use other materials than malt is a boon to brewers and a national gain, notwithstanding that farmers and maltsters lose. The public get better beer, brewers make larger profits; rice merchants and maize millers are likely to have a good time.

Farmers pleaded and demanded for upwards of a century for what they esteemed a boon, but which the irony of fate has reserved to the time when it virtually means the destruction of the last stronghold of Protection which Free Trade left them. They now come into direct competition with the foreign producer in a field which the old law helped to hedge round for their special benefit. Past experiences of similar contests leave very little room for speculation as to the result.

THE INFLUENCES OF THE BEER DUTY.*

Directly and indirectly, the influences that follow, or have been started, by the transition of the old Malt Tax into a duty upon beer are very numerous. It would be a work of great difficulty to follow these influences to their more remote ramifications, but with the experience that two years' working of the change has conferred, we can form definite opinions, and cite known facts, that will materially aid us in the discussion of so important a question. In a paper upon the subject, read at York last year, I showed that the classes that must experience the greatest loss by the change would be the farmers, landowners, and maltsters. I knew that brewing as an industry would gain some advantages that experience alone could satisfactorily determine, to counterbalance the positive and assessable loss. It was known and discussed that small common brewers would be pinched. Few, however, were prepared for the almost total extinction of their class that now threatens speedily to ensue if the present rate of this falling off is maintained. Large brewers do not gain trade to an extent proportionate to the rapid suppression of so many small businesses. The labouring classes gain the questionable benefit of making bad beer 20 per cent. cheaper than they can buy good.

Actual experience now shows that the direct gainers by the change are at present:—

1. The National Revenue (Excise branch).
2. The lowest section of the labouring classes, living in houses of a value of less than £10 or £14 per annum.
3. The section of the community that makes gain of the other materials than malt and sugar now used in brewing.

The direct losers are:—1. Farmers; 2. Brewers, more particularly small ones; 3. Maltsters. The indirect losers are landowners, and the numerous sections of the community who more or less directly depend upon these losers.

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* Paper read by H. STOPES at British Association Meeting, Section F, Southampton, August 25, 1882.

Experience is not yet sufficiently long to show if larger brewers, as a class, are gainers. Some gain slightly, but very many lose. It is also unnecessary at present to trace out the indirect gainers and losers.

The points I wish to establish are:—

I. The present duty exceeds the old tax.

II. The loss occasioned presses heavily upon a body of men ill able to bear it; to wit, the farmers, small brewers, and maltsters.

III. The moral and social disadvantages of the 6s. and 9s. licences, and the desirability of their suppression.

IV. The advantages of the free mash-tun.

I. That the present beer duty exceeds the old Malt Tax was freely admitted by Mr. Gladstone in his budget statement this year, and is clearly and incontestably shown by the parliamentary returns moved for by Mr. Watney, in which are set forth the numbers of brewers, licensed victuallers, &c., in the United Kingdom, together with the quantities of malt, corn, &c., used, and the amount paid as duty during the year ending September 30, 1881.

This was the first entire year of the working of the beer duty, which came into force October 1, 1880. The lowest duty paid by any class during the year was 23s. 6¾d. per quarter by the 1,677 brewers, brewing between 1,000 and 10,000 barrels per annum. A number of these men brew badly, and secure a ruinously small extract from the material used. Others of this class, on the other hand, secure larger extracts and pay higher rates of duty than even the very largest brewers. But, bad as the whole average is, it nevertheless secured to the Excise the payment of upwards of 10d. per quarter—more than would have been paid had these same men used the same quantities of material, paying duty upon the old plan. Originally the duty stood at 22s. 8d. per quarter, and to this was added 1s. per quarter brewer's licence, making the total payment upon material used 22s. 8d. per quarter of malt or its equivalent of sugars. The total quantity of material used by these 1,677 brewers amounted to over one and a half million quarters, or an average of 920 quarters each, and their extract was under 83, or slightly in excess of the assumed possible extract.

It is extremely remarkable that men doing a business so considerable should have their extract fall below that of the 14,948 smaller brewers, who each average only forty-four quarters malt used per annum. The fact is so significant that it compels an inference to be drawn, which I may be pardoned for not expressing publicly. The quantity of materials used by these smaller brewers falls short by 23,597 quarters of that brewed by the three largest brewers. It is fair to assume that the really large amount of material of 667,440 quarters is used by this class in the least scientific manner, and with the worst appliances. Still, the fact remains that last year they paid, upon the wort produced, and not upon materials entered, 23s. 9½d. per quarter, or 1s. 1d. more than would have been paid as a malt tax. The succeeding 482 brewers used 4,160,776 quarters materials, and paid an average of 24s. 4d. per quarter, which makes 1s. 8d. per quarter more than the old charge, and the three largest brewers of all using 691,038 quarters materials, or an average of over 230,000 quarters, each paid 25s. 3d. per quarter, which exceeds the former payment by 2s. 7d. per quarter. The largest brewer but one exceeded the former charges by 3s. 2½d. per quarter.

These calculations are not so accurate as a question of such importance merits, because of the insufficient details furnished by the returns. It is impossible even to conjecture the quantities of material other than malt or sugar entered. Many thousands of quarters of raw and prepared grain, and syrups or wort extracted in a variety of ways from maize, rice, and many other forms of grain, have been used, not only experimentally, but on a considerable scale, and owing to the amount of extract so obtained being not identical with the yields of malt or ordinary sugar, they affect this question to a considerable degree; but the broad general fact is unaffected that all materials used by brewers for sale paid an excess of duty over former years of 2s. per quarter.

Mr. Gladstone freely admitted this in his budget statements. In the *Times** report of his speech he says :—

" It is still stated with confidence by the other side—namely, " by the brewers of the country, who represent and speak for " the entire trade—that we have pitched the beer duty too " high, and that we have received fully 2s. a quarter more in the " shape of beer duty upon the quarter of barley used in brewing " than we received formerly from the malt duty. Happily it " is always a very great advantage when there is no serious " dispute upon the fact. Upon the whole, we do not deny that " statement. We plead guilty to the soft impeachment thus " far—that to an amount at any rate closely approaching to 2s. " we received it; but we contend that we are entitled to that " profit, and upon that subject there is a friendly argument " carried on in the best possible humour between the members " of the trade and ourselves."

It is a little singular that the Chancellor of the Exchequer, although freely admitting that the beer duty causes an additional charge to common brewers of about 2s. per quarter, nevertheless shows that for the first entire year of its collection the Excise Revenue suffers an apparent loss of £92,000. He states (*Times*) :—

" We estimated, as I have said, the total produce of the beer " duty for the year at £8,800,000. That estimate was taken " rather high in partial deference to the estimates of gentlemen " connected with the trade. They felt so great a confidence " in the view they presented as to the mode in which we had " framed the law for the benefit of the Exchequer, and their

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* April 25, 1880.

" knowledge and experience were so considerable, that a small " addition was made to the estimate merely out of deference to " them. The estimate had been taken at £8,800,000, the actual " yield has been £8,580,000—that is, £220,000 short of the " estimate. The estimate of the Revenue Department would " have been very close indeed, but for the circumstance which " I have mentioned. The committee will be anxious to compare the proceeds of the beer duty with those of the old malt " duty. If we compare the beer duty of the year just expired " with the malt duty we should compare it with the last complete year of the malt duty, the year 1879-80, when the product of brewing in all its forms, malt, sugar, and licences, " yielded £7,737,000, so that we appear to have gained £843,000. " That is entirely fallacious, for during that period the harvests " were bad and the depression of trade was so great that there is " no fair standard of comparison. I have taken, therefore, for " the purpose of comparison the six preceding years of the " malt duty, and I find that the average revenue from the malt " duty, together with the sugar used in brewing and the " licences, for the average of the six preceding years from 1873 " to 1879, was £8,672,000; that is, that the malt duty upon an " average of years produced £92,000 a year more than " we have got out of the beer duty on the first full " year of the beer duty. Effectively there is in point of " fact for the time a small diminution. Obviously, as I " have admitted, we get nearly 2s. a quarter in the beer duty " as compared with the old malt duty, and, as I have also " shown that, notwithstanding the increase of population, our " receipt from beer duty is less by £90,000 than the average " receipt from the old malt duty in the years between 1873 and " 1879, I represent a state of facts in which there is some " collapse somewhere. Is that collapse due to any alteration " in the habits and practices of the people? The Board of " Inland Revenue officers, whom I consider to be good authorities on the subject, do not exclude that supposition, but " they do not look to it as the main cause. They say that " although employment in the country is general, yet wages " have not yet reached the full average level, and undoubtedly " have not reached anything like the level which they reached " in the years of prosperity between 1873 and 1879. They also " observe, and I have no doubt there is something in this, that " last year in the cider counties there was a very great abundance of fruit, and a very large consumption of cider. Then " comes another fact—the great increase of coffee-houses and " clubs, which lead to the supposition of more temperate " habits, and which are a proof of this deficiency in the " revenue."

Admitting the force of all these observations (although practically it is hard to accept some of them), the influence of the small householder's licences ought not to be ignored. Last year over 120,000 of these licences were taken out, chiefly in agricultural districts, producing £46,000 to the revenue, and giving an average of under 2¼ bushels as the quantity of material used by each licensee. The actual quantity used by each of these small licence holders is estimated to exceed two quarters. Had this malt paid the same duty as if used by common brewers, it would have produced upwards of £300,000 to the revenue, and turned the apparent loss of £92,000 to an actual gain of over £200,000. That this estimate is too low is confirmed by the fact that 7,000,000 quarters malt at 1s. per quarter= £350,000, assuming that the additional charges for collection, and other considerations, which we need not dwell upon here, reduce the net gain to the revenue from the beer duty to 1s. per quarter.

No more time need now be taken to prove the generally recognized increase of duty paid. That this loss is not larger than it is known to be is the brewers' own fault entirely.

II. The loss occasioned by the change of duty presses heavily upon farmers and small brewers, many of whom are unable to bear it.

Farmers do not require elaborate and far-fetched argument to prove that the repeal of the Malt Tax is a loss to them. They have had two years' practical demonstration in the market value of barley, and are more than likely to get a third, for it is very difficult to conceive any combination of circumstances, apart from legal enactments, that can give barley so high a value as it previously had. Bad seasons formerly had the compensation of higher prices for the produce, and it was some satisfaction to those men who were favoured in their crops, especially those who secured some barley of fine quality. The competition amongst brewers, and the peculiar facts which I somewhat fully defined at York, made prices rise to a point which would now be unattainable. Directly barley reaches a certain price, the advantage in actual cost of other grains makes it desirable to brewers to commence their use. Consequently, if half this year's barley rots in the field and is never garnered, brewers could be comparatively indifferent, for other countries and climes can yield not only barley, but maize, rice, and other things that can now be economically and satisfactorily used in its place. Besides, the change in the law has made many classes of foreign and English barley capable of economical use, malted or even unmalted, that were formerly excluded.

When a monopoly is removed, when political laws are altered, or the more rigid physical laws are permitted to have free course, so that in a great national industry the choice of varied and cheaper material is suddenly made free, the value of any given natural product previously used exclusively must necessarily be depreciated. Barley, in brewing, is an illustration of this truth. Should any change in the laws be effected to remedy the result, it will be futile and ineffective unless the tax is placed upon its old basis. Protection tariffs placed upon rice, maize, &c., may exercise a little influence, but not much.

Hence every grower of barley in Great Britain suffers the loss of the difference in price his crops actually yield compared to what they would have done had the Malt Tax continued. This loss is fairly the tax farmers have brought upon themselves in demanding the repeal of the Malt Tax. As unfortunately it is coincident with, let us hope, the termination of a long period of agricultural depression, it is a loss hard to bear, and to many small farmers it has turned the scale against them, and they have broken under it.

To small brewers the loss occasioned by the change is even more disastrous. Owing to the general and long-continued depression of trade and the lower average wage of the beer-drinking classes, the whole brewing industry has been in a drooping and depressed state. A few of the larger businesses have grown, but the general tendency has been to decrease. If we take the last year, and compare it with 1880, we find that the greatest brewer apparently stands still at over 1,000,000 barrels. The second has decreased, having paid duty on under 950,000 barrels last year, and over it in 1880; but I believe I am correct in stating what I have heard in many places and on high authority, that our great English brewery, which brewed over a million barrels last year, has taken second place, and an Irish brewery now heads the list. As some significant facts arising from this phenomenon do not concern us here, I pass them by. The third on the list has risen during the year from under 800,000 barrels to over it; but the fourth has fallen from over 550,000 barrels to under 500,000 barrels. Instead of sixty-one brewing between 100,000 and 500,000, we have only fifty-six; also 2,205 brewing between 1,000 and 100,000, we have only 2,103—a loss of 102. Instead of 16,770, exclusive of beginners, under 1,000 barrels, we have only 14,948—a loss of 1,822.

To arrive at the number of small brewers who have given up the struggle during the year, it is necessary to know how many have had their trades increase sufficiently to carry them from class 1 to 2, and also how many have fallen from classes 2 and upwards down to class 1. As the trade is manifestly experiencing a sharp depression, it is perfectly fair to assume that the latter far exceed the former.

In 1880, 2,183 beginners are added to the list, but the numbers of beginners in 1881 are not given; these, however, do not affect the question, as a beginner in 1880 must either have ceased business, or be included in class 1. The numbers of those who gave up in a few months are insufficient to affect the totals greatly, and certainly not to affect the deductions made. Hence we find that on September 30, 1880, there were—

	Brewers brewing over 500,000 bls.	Ditto over 100,000 bls.	Ditto over 1,000 bls.	Small and Beginners.	Total.
1880	4	61	2.205	18,953	21,223
1881	3	56	2,103	14,948	17,110
Decrease ..	1	5	102	4,005	4,113

So that in this one year alone the loss of brewers (and beginners) has reached the startling total of 4,113.

These figures furnish the proof that small brewers are rapidly disappearing—so rapidly, indeed, that in a few years they will entirely cease to exist if the present rate continues. The causes that produce this result have been multiplied and intensified by the change in the law. The natural laws ruling supply and demand, and the caprice of the popular taste, would doubtless have produced the same result, only it would have been much more slowly attained. The operations of the new Act have been:—

1st. To add directly to the burdens of small brewers; and,

2nd. To deprive them of a large number of the most lucrative and best of their customers.

Small brewers, as a body, almost without exception, have not sufficient scientific or technical training to use other materials than malt rightly; nor the appliances to use malt alone profitably. They therefore have to bear the whole of the losses entailed by the new Act, and cannot secure to themselves any of the advantages. What these losses are can be more fully appreciated by a comparison of the three largest brewers with the 14,948 smallest. These three brewers used materials representing 691,038 qrs. in 1880-1, paying duty amounting to £871,066 8s. 9d. The 14,948 used materials representing 667,441 qrs., paying duty amounting to £792,718 15s. 2¼d., a difference of £78,347 13s. 6½d. Had the small brewers used 23,597 qrs. more material, making the quantity equal, the difference in duty paid by the two classes would have been £50,277 1s. 9d. So that were all the small breweries swept away, and the work done by the largest, the revenue would gain over £50,000 a year direct duty, apart from the great difference in cost of collection of the duty from three giant establishments instead of nearly 15,000 tiny places, scattered here, there, and everywhere.

What is of more importance and value is the fact that the superior scientific treatment of this great amount of valuable and costly material would have resulted in a gain of extract of 5 lbs. per quarter, which, under the circumstances, is estimated beneath its true value at 1s. 3d. per lb., and would exceed £200,000, or, in other words (and this is the more accurate way of regarding it), the mere gain in extract by intelligent use, with proper appliances, would have produced 166,360 barrels of beer of good gravity, worth at least £250,000, which, after payment of the duty, would have been very largely sheer profit to the brewers. Large as big brewers' profits are known to be, it nevertheless shows clearly that little brewers work on small profits, or at a loss, and their rapid decrease confirms the fact. Further, almost all the holders of the cheap householder's licenses were, until last year, good customers of (chiefly) the small brewers in agricultural or manufacturing outlying districts. As a rule they were heads of families using large quantities of beer, and paying regularly and well for it. As they now can brew beer more cheaply, and, in many cases, quite as well as the brewers they deal with, they do so, and numbers of tiny breweries have disappeared. Owing to the loss of this custom, maltsters are standing still. Like prisoners who have been kept in chains so long that liberty, when it comes, is irksome, they have been tightly bound by the law so many years that their sudden liberty passes them by, as a body, almost unnoticed, and they adhere to their old practices and ideas, and refrain from making alterations or experiments. They hesitate even to take the benefits of the experience acquired in other countries by their co-traders. A very small number have secured to themselves the advantages open to all, and improved malt at less cost is their reward; but the old generation will nearly pass before malting rises to the level of what it is now known it ought to be, much less of what it may be. Small badly-worked maltings will share the same fate as small breweries. Small maltsters are badly pinched, and large ones complain greatly as a rule. Unfortunately, we have now no longer the carefully prepared tables and statistics of the honourable Commissioners of Inland Revenue, so that mere opinions can be given, and few actual facts.

Landowners suffer chiefly, indirectly, through their tenants, excepting in those cases where they cultivate their own land. But the question of indirect loss and suffering is too involved to be embraced within the limits of a paper of this kind.

III. We will now pass to my third point—The moral and social disadvantages of household licences and the desirability of their suppression.

Brewers naturally cannot be expected to look with favour upon these licences. The marvel is, they do not try to offer a more decided opposition to them. Leaving, however, all trade consideration entirely out of sight, the social and economic disadvantages are sufficient to render their continuance undesirable. Class legislation has usually little to commend it. In this instance, brewers have to pay a heavier duty to enable that class of the community that can least appreciate it, and use it only in (it is to be feared) the worst way, to make very large quantities of beer entirely free from duty. This one question alone is sufficient to raise a long discussion amongst political economists. Time will not permit me to do it justice, nor is it really necessary here. Practically looked at, it cannot be right to allow the very great waste that inevitably occurs in the considerable quantities of material spoiled by these amateur brewers. If a man is unable or unwilling to pay a higher rent than £10 or £14 per annum, it seems undesirable to so frame a law that he can get a commodity duty free that has been taxed for two and a half centuries. If this principle were put into general practice, so that spirits, tobacco, tea, and other exciseable articles were to be also procured duty free by occupants of cheap houses, I question very much if society would bear it so quietly. If, on the other hand, a man occupies a house valued at £15 per year, it seems decidedly unfair that he must pay a duty of 25s. per quarter on the malt and hops he brews, whilst his neighbours escape entirely.

It is difficult to comprehend the difference between one labourer in Suffolk turning his malt into beer, and others, in Fifeshire or Tipperary, wishing to convert theirs into whiskey. The additional stimulus given to one form of the truck system, that has somehow managed to survive in some districts, is a generally admitted evil. Labourers are paid in malt and hops, or in beer, instead of money. It is a pernicious plan, and cannot be defended on any ground whatever.

Hence upon moral and social considerations the reconsideration of this slight advantage to farmers should be urged upon the legislature. It is true it seems the only benefit they get from the repeal of the Malt Tax, and it looks unkind to deny it them, but the whole is greater than a part, and justice to the whole community is of more worth than a small and questionable favour to one or two classes, however poor and suffering they may be.

IV. The Advantages of the Free Mash-tun.—Having taken such a broad general view of this subject, it is undesirable to leave it at this particular time without briefly glancing at the question of the free mash-tun. It has for some time occupied considerable thought and attention, especially in interested quarters. Notwithstanding the pressure of Irish, Egyptian, and other important business, it has even appeared in the House of Commons. Thus far, if my paper be carefully read, it will be found I have been complaining of defects and evils rather than pointing out such stray crumbs of advantage as by diligent seeking may possibly be found; but before concluding I turn to one direct result of the new beer duty, which is a genuine advantage, although, of course, like all other good things, it does not meet with universal commendation. Free trade has its advantages questioned, and so doubtless will the free mash-tun. To the brewer it gives the opportunity to make better beer in a better manner at less cost. It allows the real laws of pure beer production to be carefully investigated and faithfully followed. Choice of material being freely permitted by human law, it does not follow that natural law will admit of impurity and adulteration being freely indulged in by brewers. They cannot do it if they would, and of the vast majority it may in justice be said they would not if they could. Maize, rice, and sugar may be looked upon by farmers as adulterants because they interfere with the price of barley, but it does not follow that they are such. Sugar has been freely used for many years, and the limit of its use is fixed by immutable laws regulating the vitality of the yeast-plant. Other materials are innovations, but how a man can determine that products of starch from barley are good, and the same from rice or corn are baneful and injurious adulterations, I cannot see. Farmers are raising the cry that any material used in brewing excepting malt, hops, and sugar is an injurious adulterant. This is a very foolish cry, and it seems remarkable how farmers have turned round and embraced their old enemy sugar. Any description of corn, when rightly treated, is capable of producing a purer wort than sugar. The starch and other soluble matters obtained from wheat, rice, maize, or even dhoura, approximate more closely the natural extract of malt, and are capable of making a more natural and healthful wort and finished beer than can be got from cane-sugar. But assuming that such material be forbidden (and such follies sometimes happen), then the liberty to use malt rationally will be a great benefit to intelligent men, unless, indeed, the farmers would restrict that also.

For the public, the free mash-tun ensures sounder and better beer, and so long as beer remains the national beverage and can be termed a "Nectar meet for the gods," this is a consideration that will weigh against the clamours of that class who, having gained the great benefits of the repeal of the Malt Tax, will find the advantages of the protective mash-tun (if they succeed in gaining it) of equal value to themselves, but a far greater loss to the general community.

Amounts received for Malt Duty, Number of Maltsters Licensed, and details of Malt made since 1858.

Malt duty received in year ending 31st March.		No. of Maltsters licensed in year ending 31st March.	Bushels of Malt in year ending 31st March.		
			Charged with Duty.	Exported on drawback (*a*). Duty free (*b*).	Made Duty free.
	£				
1858 ..	5,326,022	6966	41,164,254	—	5,425,332
1859 ..	5,412,777	6909	42,794,049	255	5,162,360
1860 ..	6,648,881	6798	44,564,986	—	5,380,407
1861 ..	6,208,813	6565	37,366,554	104,751	4,384,317
1862 ..	5,866,302	6545	45,555,914	210,831	4,112,401
1863 ..	5,389,909	6250	41,064,830	202,365	4,410,687
1864 ..	6,092,736	6207	47,930,949	212,735	4,981,053
1865 ..	6,394,553	6112	48,538,413	247,985	5,092,169
1866 ..	6,421,260	6021	50,163,487	368,846	4,995,792
1867 ..	6,816,386	5821	50,915,828	457,701	—
1868 ..	6,302,419	5696	48,489,439	252,168	—
1869 ..	6,527,708		49,590,510	345,787	—
1870 ..	6,483,612	5417	50,697,459	(*a*) 116,025 (*b*) 475,519	5,119,507
1871 ..	6,978,371	5332	52,929,392	(*a*) 96,148 (*b*) 359,974	5,463,265
1872 ..	6,670,955	5148	52,061,010	(*a*) 63,558 (*b*) 493,533	5,400,238
1873 ..	7,544,175	4977	57,213,785	(*a*) 32,003 (*b*) 407,754	6,171,006
1874 ..	7,753,617	4801	59,437,976	(*a*) 29,485 (*b*) 513,303	6,230,355
1875 ..	7,746,740	4690	59,722,561	(*a*) 27,131 (*b*) 409,860	6,204,643
1876 ..	7,654,681	4587	58,993,409	(*a*) 29,981 (*b*) 468,010	6,693,665
1877 ..	8,040,378	4425	60,526,682	(*a*) 59,943 (*b*) 451,749	7,109,409
1878 ..	7,721,548	4251	58,137,196	(*a*) 54,212 (*b*) 482,172	7,520,822
1879 ..	7,739,507	4114	58,036,155	(*a*) 35,937 (*b*) 471,868	7,225,212
1880 ..	6,732,279	3835	50,341,799		6,827,139
1881 ..	2,676,482		10,396,158		1,409,968

For full details for all earlier years, see the First Report of the Commissioners on the Inland Revenue, 1857, Appendix pp. xliii. xliv. lxvii.

*Quantities of Malt made and Average Prices of Barley each Year for the last Century.**

Year.	Bushels.	Average price of barley per qr.	
		s.	d.
1781	26,146,789	17	8
1782	28,015,043	23	2
1783	17,288,809	31	3
1784	26,609,088	28	8
1785	27,096,338	24	9
1786	22,770,022	25	1
1787	27,272,841	23	4
1788	26,868,996	22	8
1789	24,250,510	23	6
1790	22,669,579	26	3
1791	27,923,505	26	10
1792	28,694,962	26	2
1793	24,453,901	31	1
1794	25,595,351	31	9
1795	24,715,955	37	5
1796	28,142,815	35	4
1797	30,923,923	27	2
1798	26,967,367	29	0
1799	31,776,690	36	2
1800	14,492,537	59	10
1801	18,573,251	68	6
1802	30,360,173	33	4
1803	30,493,707	25	4
1804	22,542,859	31	0
1805	22,347,999	44	6
1806	27,492,395	38	8
1807	24,920,289	39	4
1808	22,411,138	41	2
1809	22,818,143	47	0
1810	24,288,426	48	1
1811	26,801,604	42	3
1812	18,663,178	66	9
1813	22,385,292	58	6
1814	26,118,612	37	4
1815	27,073,982	30	3
1816	26,260,549	33	11
1817	17,139,712	49	4
1818	26,462,932	53	10
1819	22,344,271	45	9
1820	24,535,005	33	10
1821	28,697,057	26	0
1822	25,151,507	21	10
1823	26,873,937	31	6
1824	27,939,072	36	4
1825	28,553,399	40	0
1826	32,480,678	34	4
1827	29,613,501	37	7
1828	36,794,206	32	10
1829	29,153,177	32	6
1830	32,962,454	32	7
1831	39,252,269	38	0
1832	37,390,455	33	1
1833	40,075,895	27	6
1834	41,145,596	29	0
1835	42,892,054	29	11
1836	44,387,719	32	10
1837	40,551,149	30	4
1838	40,550,566	31	5
1839	39,939,941	39	6
1840	42,456,862	36	5
1841	36,164,448	32	10
1842	35,851,394	27	6
1843	35,693,890	29	6
1844	37,187,186	33	8
1845	36,545,990	31	8
1846	41,969,000	32	8
1847	35,307,815	44	2
1848	37,545,912	31	6
1849	38,935,460	27	9
1850	40,744,752	23	5
1851	40.538,102†	24	9
1852	41,123,646	28	6
1853	42,154,140	33	2
1854	37,012,382	36	0
1855	35,388,170	34	9
1856	42,892,188	41	1
1857	45,967,461	42	1
1858	46,654,986	34	8
1859	49,507,728	33	6
1860	48,551,149	36	7
1861	47,934,614	36	1
1862	49,668,315	35	1
1863	45,475,517	33	11
1864	52,912,002	29	11
1865	53,630,582	29	9
1866	55,169,279	37	5
1867	55,749,649	40	0
1868	53,023,900	43	0
1869	54,612,671	39	5
1870	50,946,544	34	7
1871	52,889,032	36	2
1872	52,211,924	37	4
1873	58,090,442	40	5
1874	59,617,497	44	11
1875	60,275,523	38	5
1876	60,057,453	35	2
1877	61,723,080	39	8
1878	60,192,935	40	2
1879	59,267,755	34	0
1880	51,756,515	33	1
Half year	11,054,666		—

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* For fuller details of quantities made, and duties paid, see Reports of Commissioners Inland Revenue.

† Inclusive of export, duty free.

Number of Maltsters in Britain.

	Number of Maltsters Paying Duty.	Number of Malthouses Licensed.
1851	8,166	11,048
1860	6,499	10,086
1870	5,417	—[*]
1871	5,323	—
1872	5,148	—
1873	4,977	—
1874	4,801	—
1875	4,690	—
1876	4,587	—
1877	4,425	—
1878	4,251	—
1879	4,114	—
1880	3,835	—

The number of maltsters entered in the Census Returns for 1881 are as follows:—

	Age under—						
	15	20	25	45	65	Over 65	
Males	44	484	1,182	4,671	2,553	539	England & Wales.
Females	—	2	3	11	29	13	
Males	2	17	50	156	77	17	Scotland.
Males	2	46	106	402	191	37	Ireland.[†]
Females	—	1	—	4	—	—	
	48	550	1,341	5,244	2,850	606	Total 10,369

The importance of the barley crop is best indicated by the following extract from the *Times*, October 20, 1883:—

The barley crop, which is next in importance to wheat, is believed to be this year up to a full average. Here, again, we have to ask, What is this standard average yield per acre of barley? For the 40 counties of England the average is by the earliest estimate 37 bushels, by the Central Chamber 34 1-3, and by the last seven years' average 35 bushels per acre: of the United Kingdom, according to the 1870 estimate, 37 bushels; of Great Britain, according to the 1882 estimate of Major Craigie, 34 2-3 bushels; of England and Wales, according to the seven years' average, 34¼ bushels per acre. If we adopt 36 bushels as the standard gross yield for the United Kingdom, and deduct three bushels as the average seeding, we have the average of four quarters per acre available for consumption in brewing, distilling, and grinding for animals.

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[*] Details not furnished in Commissioners' Report.

[†] These figures also include distillers. The number of maltsters, or men and women engaged in malting, is considerably influenced by the date of making the returns, and the imperfect division between distillers, distillers' labourers, maltsters, and maltsters' labourers.

Standard Average Yield of Barley in England, in Bushels per Acre, according to the Estimates of different Authorities.

County.	J. Algernon Clarke, 1870, Standard Average.	Major Craigie, 1882, Twenty Years' Average.	"Mark Lane Express," 1882, Seven Years' Average.	Means of the Three Estimates, in bushels and decimals.
Kent..	40	40⅔	42	40·9
Cambridgeshire	39½	37½	38¼	38·4
Essex	39½	38	37	38·1
Northampton	38½	37½	37⅓	37·8
Lincolnshire	39⅓	34½	38½	37·5
Norfolk	36½	37	37½	37·0
Oxfordshire .. .	39½	35¾	35⅔	36·9
Suffolk	36	36⅓	37⅓	36·6
Nottinghamshire	41	34½	33	36·1
Yorkshire	39	34¼	35¼	36·1
Hertfordshire	37	37	33	35·6
Wiltshire	37	32½	29⅔	33·0
Hampshire	36½	32¼	30	32·9
Mean of 13 Counties ..	38⅓	36	35¾	36·7
Average for England ..	37	34⅓	35	35·5

The home produce and imports for last year, and the produce for the present harvest, appear to be as in the following table:—

	Harvest year, September, 1882, to August, 1883.	Harvest year, September, 1883, to August, 1884.
Acres of Barley grown	2,452,000	2,485,000
Yield per acre..	5 per cent. under average 33¼ bsh.	Average, 35 bsh.
Produce available for consumption, after deducting seed, in imperial quarters	9,272,000	9,940,000
Imports in imperial quarters ..	4,398,000	?
Total supply available for consumption in imperial quarters	13,670,000	?

On a slightly larger acreage than last year we have grown a much better crop, valued at 9,940,000 quarters, after deducting seed, or two-thirds of a million quarters more than last season. The quality is very varied; a fair portion of the barleys in the eastern and southern counties is fine, bright, and harvested in good condition, but much, nevertheless, is inferior, steely, or discoloured, and a proportion badly treated by the weather. Coarse quality prevails to a great extent in the north. The imports in the harvest year, September, 1882, to August, 1883, amounted to 4,398,000 quarters, and there were no exports to deduct. The total supply, leaving stocks in hand out of the question, was, therefore, according to this estimate, 13,670,000 quarters. At this rate we ought not to require from abroad so much as 4,000,000 quarters during the current twelve months ending next August.

The following return, showing the sales of home-grown barley and the average price realised in the principal markets of England and Wales in each week for four years from the commencement of September, 1879, may be of interest and value, as indicating the course and relative sales upon such markets as made returns at the periods named.

Week ended.	1879.			1880.			1881.			1882.		
	Qrs.	s.	d.	Qrs.	s.	d.	Qrs.	s.	d.	Qrs.	s.	d.
Sep. 2	343	32	11	398	35	0	432	32	10	1,118	36	2
,, 9	845	36	8	1,795	35	1	1,151	34	6	2,371	36	0
,, 16	2,198	43	2	5,846	33	5	3,709	35	7	7,186	36	11
,, 23	5,402	41	11	14,769	34	0	8,149	35	0	19,058	36	1
,, 30	9,689	40	7	21,221	34	0	18,919	35	1	40,414	34	10
Oct. 7	19,212	40	9	40,954	34	2	32,360	34	10	54,084	34	4
,, 14	26,407	40	10	58,062	35	2	43,812	34	9	76,770	34	0
,, 21	36,432	40	10	63,830	35	2	53,442	35	8	82,751	34	5
,, 28	58,525	41	1	82,164	35	11	62,929	35	4	80,628	34	4
Nov. 4	57,447	40	8	79,961	35	2	67,884	35	2	88,404	34	5
,, 11	72,569	40	1	93,610	34	7	74,645	34	9	80,178	34	1
,, 18	72,275	39	8	88,276	33	9	70,882	34	6	89,932	34	4
,, 25	79,041	38	10	84,542	33	6	92,535	33	6	94,502	34	4
Dec. 9	81,590	38	7	82,735	32	8	82,068	32	6	93,261	34	5
,, 16	80,701	38	0	76,083	31	6	75,774	31	8	89,036	33	8
,, 23	68,732	37	11	71,431	31	3	74,265	31	6	83,468	33	1
,, 30	51,071	37	7	49,312	31	5	57,806	31	6	70,919	32	8
Jan. 6	40,666	36	8	39,344	31	6	50,610	31	10	47,558	32	4
,, 13	66,696	37	2	62,638	32	1	66,366	32	9	55,282	32	3
,, 20	64,088	37	3	70,755	32	7	76,763	33	2	78,112	32	6
,, 27	58,242	36	4	56,313	32	5	75,888	33	4	74,160	32	9
Feb. 3	63,354	36	10	53,273	33	2	68,493	32	2	70,469	32	9
,, 10	51,008	36	10	54,412	32	9	58,136	32	5	66,032	32	10
,, 17	41,646	35	11	48,952	32	1	52,521	31	10	56,176	33	1
,, 24	33,655	35	2	43,324	31	10	42,726	31	4	53,595	33	5
Mar. 3	30,343	38	2	45,983	31	7	37,778	30	8	42,844	33	8
,, 10	27,689	34	10	40,537	32	1	35,677	30	5	50,952	33	7
,, 17	21,816	34	11	36,596	31	8	30,090	30	0	44,350	33	11
,, 24	20,637	34	5	32,113	32	2	42,425	30	1	40,150	33	3
,, 31	12,502	35	0	25,946	32	2	21,579	30	11	29,965	33	1
April 7	10,344	33	9	15,573	32	0	16,267	30	0	21,252	33	2
,, 14	9,487	33	8	13,224	32	1	8,595	28	7	15,575	33	3
,, 21	7,628	32	8	10,487	31	11	8,870	28	9	12,564	32	10
,, 28	5,564	33	6	7,340	31	6	12,066	30	7	11,787	32	9
May 5	4,149	33	4	7,180	31	5	7,137	28	5	5,834	32	4
,, 12	2,803	32	2	4,981	30	9	5,072	28	9	3,696	31	4
,, 19	1,480	32	8	2,332	31	10	3,850	27	11	1,934	30	8
,, 26	539	33	4	1,661	31	9	2,440	28	4	2,517	31	8
June 2	583	28	4	960	30	2	1,421	28	4	861	29	3
,, 9	508	32	0	638	31	1	1,115	27	4	443	28	2
,, 16	605	30	9	219	30	5	846	26	6	863	25	6
,, 23	648	28	3	411	30	3	703	27	6	791	31	6
,, 30	380	31	11	394	29	3	756	25	10	457	29	8
July 7	433	28	5	371	27	9	858	27	4	270	28	11
,, 14	436	27	0	208	26	11	877	26	5	449	29	2
,, 21	333	27	9	186	27	5	558	27	8	624	27	10
,, 28	177	27	1	291	27	6	590	27	1	298	27	6
Aug. 4	751	25	1	215	30	1	394	29	1	236	30	0
,, 11	450	29	7	233	28	5	1,030	26	7	83	27	9
,, 18	356	29	9	192	28	5	504	26	1	399	28	9
,, 25	537	33	2	307	30	9	886	30	4	241	29	4
Total	1,382,092	34	4	1,181,402	31	11	1,638,078	31	0	1,943,729	32	4

Classified Return of Brewers for the year ended September 30, 1883, *with an Analysis thereof by* J. B. Mant.

Barrels of Beer brewed of Specific Gravity of 1057·8.		Number of Persons licensed including also those transferred during the year.	Amount of Licence Duty Paid and Beer Duty Charged.			Quantity of Materials used.						Averages.					
						Malt.		Sugar including Syrups, &c., per 224 lbs.		Total Malt and Sugar.		Total Quantity of Materials in Quarters for each Brewer.	Sugar.	Extract.		Duty.	
Over.	Under.												Percentages to total Quantity of Materials Brewed	Of all Materials in Saccharometer lbs. per Standard Qr.	Percentage of Variation from Standard.	Total per Quarter used.	
			£	s.	d.	Qrs.	Bsh.	Qrs.	Bsh.	Qrs.	Bsh.					s.	d.
—	1,000	13,864	740,571	10	8	621,277	2	15,394	5	636,671	7	46·9	2·41	79·76	− 2·81	21	7·2
1,000	10,000	1,592	1,746,724	2	3	1,336,603	0	118,062	7	1,454,665	7	931·8	8·11	83·80	+ 2·10	22	3·6
10,000	20,000	274	1,182,551	19	6	890,844	0	83,994	0	974,838	0	3,557·8	8·61	84·66	+ 3·14	22	6·3
20,000	30,000	70	605,286	2	5	453,232	2	43,830	2	497,062	4	6,291·9	8·81	85·05	+ 3·62	22	7·3
30,000	50,000	58	685,425	3	9	505,305	5	55,822	6	561,128	3	9,674·6	9·94	85·32	+ 3·95	22	8·2
50,000	100,000	40	786,385	13	9	565,833	5	77,499	4	643,333	1	16,083·1	12·04	85·38	+ 4·02	22	8·4
100,000	150,000	11	421,425	8	9	310,828	7	33,978	3	344,807	2	31,346·0	9·85	85·37	+ 4·01	22	8·3
150,000	200,000	6	311,194	2	6	230,530	0	18,043	0	248,573	0	41,428·8	7·25	87·45	+ 6·54	23	3·0
200,000	250,000	2	127,732	6	3	94,850	2	7,446	3	102,296	5	51,148·5	7·27	87·22	+ 6·26	23	2·2
250,000	300,000	2	177,952	18	9	130,527	0	9,916	1	140,443	1	70,222·5	7·06	88·51	+ 7·84	23	6·3
300,000	350,000	1	97,208	16	3	70,827	0	7,799	5	78,626	5	78,626·5	9·92	86·36	+ 5·21	22	11·5
350,000	400,000	2	246,514	16	3	170,372	0	27,401	4	197,773	4	98,886·7	13·85	87·07	+ 6·08	23	1·7
400,000	450,000	1	127,179	15	0	102,579	0	--	—	102,579	0	102,579·0	—	86·60	+ 5·51	23	0·3
450,000	500,000	2	297,397	18	9	222,462	0	16,627	4	239,090	2	119,545·1	6·95	86·89	+ 5·86	23	0·5
800,000	850,000	1	254,243	11	3	205,672	0	1,176	1	206,848	1	206,848·1	0·57	85·86	+ 4·60	22	9·9
950,000	1,000,000	1	301,689	1	3	233,750	2	4,308	6	238,059	0	238,059·0	1·80	88·54	+ 7·87	23	6·4
1,050,000	1,100,000	1	340,238	3	9	270,936	4	—	—	270,936	4	270,936·5	—	87·72	+ 6·87	23	3·8
		15,937	8,449,721	10	8	6,416,431	3	521,301	3	6,937,732	6	445·3	7·51	85·07	+ 3·64	22	3·1

3	6	9	12	3	6	9	12	HEATS		3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	HEAT
								90°	220°																																	220°
								88°	210°																																	210°
								86°	205°																																	205°
								84°	200°																																	200°
								82°	195°																																	195°
								80°	190°																																	190°
								78°	185°																																	185°
								76°	180°																																	180°
								74°	175°																																	175°
								72°	170°																																	170°
								70°	165°																																	165°
								68°	160°																																	160°
								66°	155°																																	155°
								64°	150°																																	150°
								62°	145°																																	145°
								60°	140°																																	140°
								58°	135°																																	135°
								56°	130°																																	130°
								54°	125°																																	125°
								52°	120°																																	120°
								50°	110°																																	110°
								48°	100°																																	100°
								46°	90°																																	90°
								44°	80°																																	80°
								42°	70°																																	70°
								40°	60°																																	60°
								38°	50°																																	50°
								36°	40°																																	40°

Messrs. Smith and Eastaugh, Beccles and Lowestoft. Record Sheet.

Date of Wetting. 1884.	Hours in Steep.	Steep Dip.	SPRINKLING.			LOADING.			TEMPERATURES OF KILNS.				
			Date.	Age.	Quantity, each Floor.	Date.	Age.	State.	First Day.	Second Day.	Third Day.	Fourth Day.	Firing off.
Nov. 3, m. 7	55	23·5	11, m. 8	6 days.	Bottom Floor. 12 pots.* Top Floor. 18 pots.	16, m. 8	11 days.	Fresh	E. 4, 78°	M. 6, 76° M. 10, 105° E. 6, 96°	M. 6·30, 104° E. 5, 125	M. 9, 180° M. 10, 185° M. 12, 190°	Fire blocked.
8, m. 8	55	23·3	16, m. 7	"	B. F. 12 pots. T. F. 18 pots.	21, m. 8	"	"	M. 11, 76° E. 6, 77°	M. 6, 82° E. 3.30, 76°	M. 11, 112°	M. 10·30, 174° Noon, 190°	
12, m. 6	54	25·7	23, m. 8	"	B. F. 12 pots. T. F. 18 pots.	25, m. 9	"	"	Noon, 77° E. 5, 77°	M. 6, 84° M. 9.30, 80° E. 3, 98°	M. 6, 92° Noon, 135°	M. 9·30, 173° M. 11·30, 192°	
17, m. 7	54	23	25, m. 7	"	B. F. 12 pots. T. F. 18 pots.	30, m. 8	"	"	E. 4, 73°	M. 6, 80° M. 11, 102° E. 4, 94°	M. 6, 96° E. 6, 115°	M. 10·30, 197° Noon, 180°	Rounding.
22, m. 7	54	25·7	30, m. 7	"	B. F. 12 pots. T. F. 18 pots.	Dec. 5, m. 9	"	"	Noon, 74° E. 6, 73°	M. 6, 84° M. 10, 97° E. 6, 88°	M. 8, 87°	M. 10, 154° M. 12, 195° E. 2, 192°	
26, m. 7	54	25	Dec. 4, m. 7	"	B. F. 12 pots. T. F. 18 pots.	9, m. 10	"	"	E. 4, 74° E. 6, 73°	M. 6, 75° E. 4, 84	M. 6, 94° E. 6, 124°	M. 10, 165° E. 2, 185°	

* Pot equals 3 gallons.

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NOTE.—All figures in Italics refer to the consecutive number of entries in Bibliography; Roman figures indicate pages.

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JULY 1, 1885.

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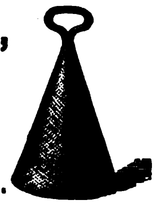

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GALVANISED WIRE DISSIPATOR.
CORCORAN'S
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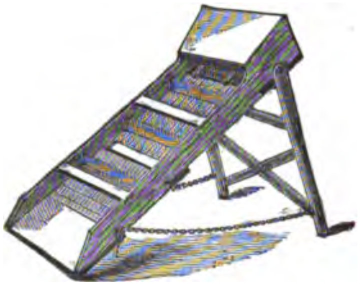

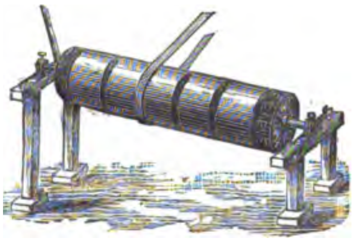

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BARLEY SCREENS.
Barley Washing & Drying Machines.
MACHINES for EXTRACTING HALF CORNS.
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TIN AND WOOD SHOVELS,
And all apparatus and tools for Malting, &c.

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Manufactories and Stores—
BACK CHURCH LANE, GOWERS WALK, BASEMENT OF CORN EXCHANGE, &c.

F. KENDALL & SON,

Analytical & Manufacturing Chemists,

STRATFORD-ON-AVON.

MANUFACTURERS OF

Pure Bisulphite of Lime

FOR BREWING PURPOSES AND FOR PREVENTING BLUE MOULD IN MALT.

Our make of the above is celebrated all over the Kingdom for its unvarying Quality and Strength, and is far cheaper to the consumer than inferior kinds.

ALSO MAKERS OF

CARBONATED FININGS.

Pure Bisulphites of Potash, Soda, and Magnesia.

Pure Dry Calcic Sulphite, for preserving Mild and Black Beers.

Mashing Powder, for use in Mash Tun.

Finishing Powder, for use in Finished Beer.

Sulphurous Acid, for cutting Isinglass.

Beer Neutraliser, for restoring and keeping Sour Beer.

Hop Equivalent, &c., &c.

Caramel, Isinglass, and other Brewers' requisites.

ANALYSES CONDUCTED ON MODERATE TERMS.

SOLE AGENTS FOR THE

NEW SYSTEM OF SUGAR INVERSION.

Descriptive Circular of above, and all particulars, post free on application.

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Consulting Brewer,

THE LABORATORY,

CROSSWELLS BREWERY,

LANGLEY, OLDBURY.

Mr. Frank Faulkner, aided by his Analytical Assistants, Messrs. Lawrence Briant, F.C.S., and Otto Overbeck, F.C.S., is open to

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WITH

BREWERS, DISTILLERS, VINEGAR MAKERS, SUGAR REFINERS, INVERT SUGAR MANUFACTURERS, AND MINERAL WATER MANUFACTURERS.

For Terms,

Apply to FRANK FAULKNER,
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BORED ✣ TUBE ✣ WELLS

Are the best means of obtaining through any strata, with expedition and at much less expense than by the old system of sinking Wells, LARGE or SMALL SUPPLIES of PURE WATER.

DUG WELLS easily deepened, and in most cases without disturbing existing Pumps.

SURFACE OR OTHER OBJECTIONABLE SPRINGS EFFECTUALLY EXCLUDED.

DRIVEN TUBE WELLS

As used by H.M. War Office for the various expeditions, and as latterly used in the SOUDAN.

These Tube Wells can only be fixed through soils free from Rocks or solid formations.

At a trifling outlay, sites can by this system be prospected previous to purchase, enabling quality, quantity, and temperature to be tested at various depths.

Any quantity can be obtained through coupling as many Wells as found necessary.

TRIAL BORINGS, PUMPS, &c.

STEAM POWER EMPLOYED FOR DEEP BORINGS.

Sites inspected and Reports furnished. Also Estimates, on application to—

C. ISLER & CO.,

ARTESIAN WELL ENGINEERS,

(Contractors to H.M. War Department)

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MAIGNEN'S PATENT

"FILTRE RAPIDE"

Is guaranteed to remove from the water all impurities, even the smallest bacteria which might interfere with the healthy condition of the Malt under process of development, or with the quality of the Beer brewed.

It is easily fixed, requires no pressure, is easily cleansed and kept in working order. The cost of maintenance is exceedingly small.

It is the only Filter now approved of by the War Office.

Important Testimonial from GENERAL VISCOUNT WOLSELEY, G.C.B.

I have much pleasure in stating that Monsr. Maignen's "*Filtre Rapide*," which was used by our troops in the expedition up the Nile, gave very satisfactory results indeed. It filtered the water both quickly and well, and was much valued by our soldiers.

WOLSELEY.

6, Hill Street, W., July 28, 1885.

All the highest Awards at the Fisheries, Health, and Inventions Exhibitions.

ESTIMATES GIVEN ON RECEIPT OF ANALYSIS OF WATER.

Maltsters who may wish to soften their water supply, so as to render it like rain-water, may do so by adopting MAIGNEN'S PATENT WATER-SOFTENING PROCESS, which is the simplest, best, and cheapest process in existence.

Write for Pamphlet on Water, Preventable Disease, and Filtration, by

P. A. MAIGNEN,

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MANBRÉ

PURE MALT SACCHARINE.

Extensively used by the Best Brewers in the Kingdom.

The fermentable Saccharine in Malt Worts will remove only about two-thirds of the nitrogenous matter it contains. The remainder is principally the cause of Beer turning sour; and the use of our Saccharine, in the proportion of one-third Saccharine to two-thirds Malt, will remove all remaining nitrogenous matter, and free the Beer from objectionable tastes.

It will increase the amount of alcohol and carbonic acid, and thereby augment the keeping property of the Beer, and make it specially adapted for export to hot climates.

It produces Beer greatly excelling in purity, in brilliancy of colour, and delicacy of flavour, the Beers brewed with Malt alone, or with Malt and Cane-sugar.

As it is sent out in small pieces, the Brewer will find no difficulty in dissolving it either in the Hop or Underback, by letting the Worts run over it, and where space is limited, it will enable the Brewing of one-third more Beer without increase of Plant.

We can, if desired, supply our Saccharine in the form of Syrup, as per Excise regulations. Particulars and prices can be had upon application.

For Samples, Prices, Terms, and References, apply to

MANBRÉ SACCHARINE COMPANY, LIMITED,

SOLE MANUFACTURERS.

WORKS: BRANDENBURGH ESTATE, FULHAM PALACE ROAD, HAMMERSMITH, W.

OFFICES: 110, CANNON STREET, E.C.

IMPORTANT!!!

By a recent Order, the Excise Authorities will allow, in future, the use of 256 lbs. of solid Glucose as an equivalent for one Quarter of Malt, instead of 224 lbs. as heretofore. This places our product in an exceptionally favourable position as regards duty, as compared with any other brewing material.

STOPES'

Patent Boiler Cleansing Apparatus

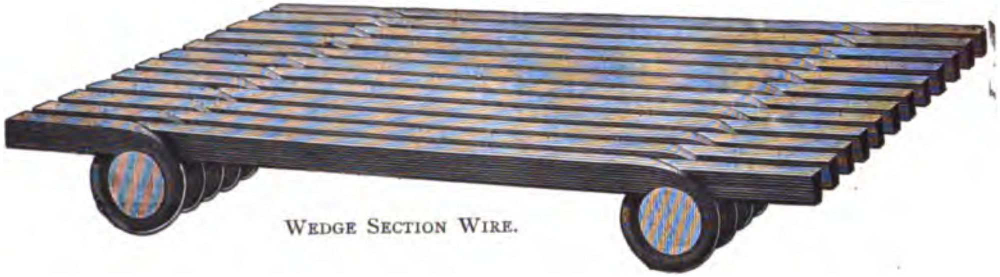
Patented in England, France, and Belgium.

This apparatus removes soot from steam boilers whilst they are at work, thereby effecting immense economy in the consumption of fuel by reason of it keeping the shell of the boiler clean, which should be exposed to the action of the fire, but is after a few days' working coated with soot, rendering this portion practically useless. The engraving shows the apparatus as fitted to Lancashire, Cornish, or Galloway boilers, and from experiments made shows, when applied to this class of boiler, a saving of fuel ranging from 20 to 30 per cent. It can readily be applied to boilers without disturbing the setting, and the great saving in coal will repay its cost in a very short time.

For full particulars and prices apply—

A. O. STOPES,
EAGLE BREWERY,
COLCHESTER.

Over **1,000,000** square feet of these Floors are in use in Great Britain, America, and the Continent.



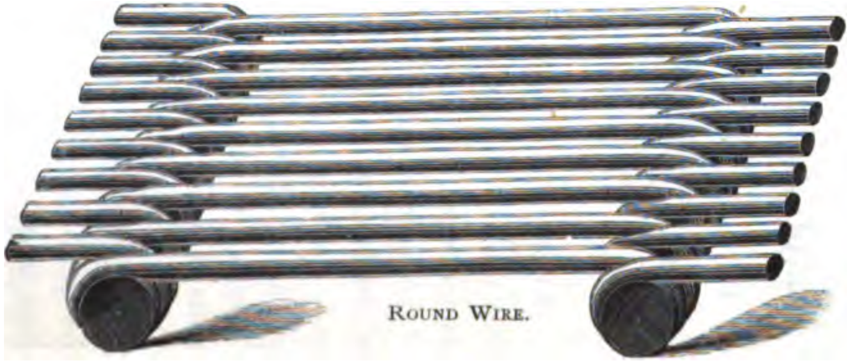
WEDGE SECTION WIRE.

They have no equal for *double* floor Kilns, or for Pneumatic Maltings. They are perfectly smooth, and therefore do no damage to grain in turning.

HERRMANN'S PATENT KILN FLOORS.

SOLE LICENSEES—LEWIS OLRICK & CO., 27, Leadenhall Street, LONDON, E.C.

Are made of the best Bessemer steel wire, in strips the full length of the Kiln. They give a ventilating space of 37 per cent., against 12 per cent. with tiles, and 17 per cent. with cast-iron plates.



ROUND WIRE.

References can be given to leading Brewers, Maltsters, and Distillers in almost any part of the country. These Floors are readily laid upon existing supports.

GEORGE CLARK & SON,

SUGAR, SACCHARUM, GLUCOSE, CARAMEL, and ISINGLASS

MERCHANTS, IMPORTERS, & FACTORS.

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MARKET BUILDINGS, MINCING LANE, AND
26, MARK LANE, LONDON, E.C.

GEORGE CLARK & SON devote their exclusive attention to the supply of Sugars to the Breweries of the United Kingdom.

BREWING SUGARS.

Raw and Refined, in Bags of 112 lbs. or 224 lbs. nett
Contracts entered into for regular Supplies.

GLUCOSE.

In Bags of 112 lbs. each nett, ex Warehouse London, Liverpool, Hull, Bristol, Newcastle, &c.

ISINGLASS.

Samples, with full Particulars, on application at City Offices.

INVERT SUGAR.

Every information given as to the Sugars best adapted for Inverting, and how to carry out the Process.

CARAMEL.

In Kegs of 112 lbs, or Casks of 5 cwt. each nett.

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ST. GEORGE STREET, LONDON DOCKS, E.

PENNEY & CO., Limited,

CITY IRON WORKS, LINCOLN.

MANUFACTURERS OF PATENT ADJUSTABLE

BARLEY SCREENS.

UPWARDS OF 28,000 SOLD.

"THE PERFECT" ROLLER MILL

MAKES A PERFECT BREWER'S GRIST.

FIRST-RATE MALT SCREENS.

MALT ROASTERS. MALT MILLS.

PATENT ROTARY LIQUOR PUMPS.

WIRE KILN FLOORS.

PERFORATED CAST-IRON MASH TUN BOTTOMS.

CONICAL STEEPING CISTERNS. PATENT SLUICE VALVES.

PULLEYS, SHAFTING, PLUMMER BLOCKS,

WORM CONVEYORS,

AND ALL

DESCRIPTIONS OF MILL GEARING.

ESTIMATES ON APPLICATION TO

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WILSON AND COMPANY.

LIMITED,

Brewers' Engineers & Coppersmiths, Vat & Back Makers,

FROME, SOMERSET.

PRESERVATION OF MALT ROLLS.

WILSON'S method of preserving Malt Mills and the restoration of old and much worn rollers is to case them with a cylinder of steel. This gives a tough and firm surface which does not become chipped or disintegrated like cast iron, however hard it may be made by chilling or otherwise, which is always a brittle metal, and is easily frittered away by the action of minute flint stones into holes through which the Malt escapes uncrushed. To remedy this, the Rolls are often screwed up too close, causing the Malt to be ground in an uncertain and unequal manner.

Copies of Testimonials forwarded on Application.

VAT AND BACK-MAKING DEPARTMENT.

WILSON & CO. have now erected new machinery of the most improved type, specially designed to turn out large quantities of work in the best and most expeditious manner, which, together with a large Stock of Timber consisting of English Oak, Russian Deals, and other Woods for Brewery purposes, enables them to execute orders for Brewing Vessels with great rapidity and at a lessened cost.

Copper Slotted False Bottoms for Mash Tuns and Hop Backs, giving ten times the amount of drainage of perforated bottoms. They never break or corrode, neither is there a mixture of metals.

Van Gelder Apsimon & Co.

Limited,

Victoria Iron Works, Sowerby Bridge,

Manufacture the most Perfected Machinery

FOR THE

CLEANSING, SEPARATING, GRADING, and POLISHING of

All Sorts of Grain or Seed

USED IN

Malting, Brewing,

AND

Distilling.

All Machines are Guaranteed to perform the workintended to be done, both as to

Capacity and Quality.

Specimen Machines, Samples of Workdone, and Testimonials may be seen at, and all further information as to Prices, etc., may be had from

MESSRS. H. STOPES AND CO.,

Southwark Street, London.

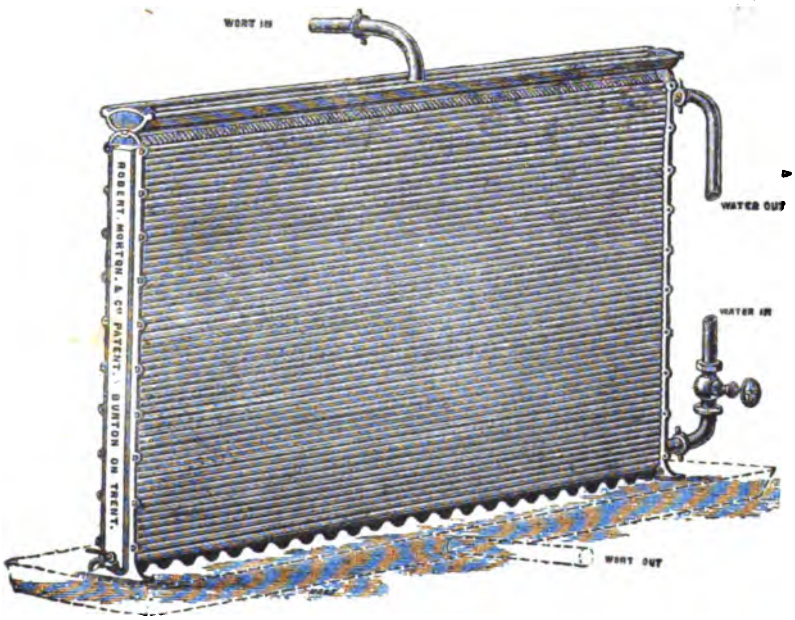
IMPORTANT TO BREWERS, DISTILLERS, ETC.

ROBERT MORTON & CO.'S

Improved Patent Vertical Refrigerator

For Cooling Brewers' and Distillers' Worts and other Fluids, the Condensing of Steam, the Cooling and Condensing of Spirits in Distilleries, &c.

Gold and Silver Medals, for refrigeration, awarded at Versailles, London, and Paris, to Robert Morton & Co., Burton-on-Trent.


WORT IN
ROBERT MORTON & Co PATENT BURTON ON TRENT.
WATER OUT
WATER IN
WORT OUT

The Advantages of these Refrigerators are as follows:—

Being made of Morton's Patent Tubes, which by a new process are drawn nearly as hard as steel, they will stand a very great pressure (although made of metal in substance little thicker than a sheet of writing paper), thus combining great strength with unequalled cooling power. Every part is perfectly accessible, so that both inside and outside the tubes can be readily cleaned with the greatest ease. These new Refrigerators are most easily repaired, and in case of a tube bursting by frost or accident, it can be replaced with a new one within an hour, extra tubes being supplied with these Refrigerators at a small cost.

ILLUSTRATED PRICE LISTS ON APPLICATION.

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Brewers' Engineers, Brass and Iron Founders, Coppersmiths, &c.,

TRENT WORKS, BURTON-ON-TRENT.

R. HOLLIDAY,

Maker of Woven Wire Floors,

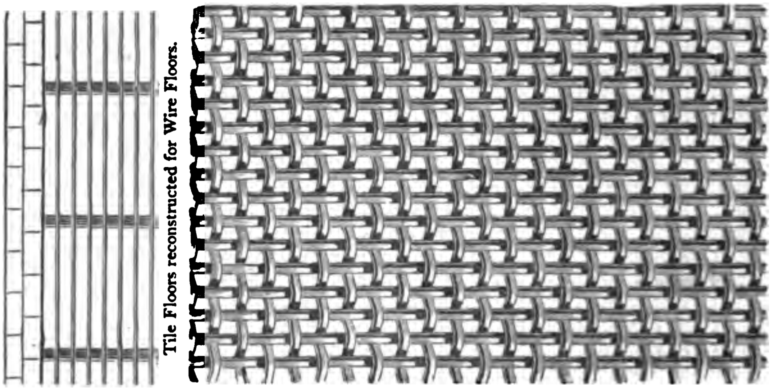
WITH IRONWORK BEARINGS,

FOR MALT KILNS,

Beaufort Street, Chelsea, S.W.

These Floors are made of the Strongest Woven Wire, and strained with Screw Bolts. Wire Floors offer the least resistance to the current of heated air passing through them, and are acknowledged to be a great saving of fuel for the same amount of heat.

Estimates given for Laying Floors complete, with Woven Wire and Ironwork Bearings.



Double Floors constructed on the same Principle.

From Messrs. Crowley & Co., Brewers, Alton, Hants.

8th September, 1883.

Dear Sir,—We have examined our Kiln Floor, and find that it has been left in a perfect state, and we are very much pleased with the way the work has been executed.

Yours truly,
CROWLEY & CO.

Mr. Holliday,
Beaufort Street, Chelsea.

From Messrs. W. Brooks & Sons, The Maltings, Mistley, Essex.

26th July, 1883.

Dear Sir,—We saw your work at Slough, on Monday, and are satisfied. If you carry out any we give you as well as that is done, we shall have no cause of complaint.

Yours truly,
W. BROOKS & SONS.

Mr. R. Holliday.

(The Floor referred to was laid by me for Messrs. Neville, Reid & Co., and measured 36 ft. by 36 ft. Messrs. Brooks and Sons then entrusted me with the laying of their floor, 52 ft. by 26 ft., and afterwards sent the following testimony.)

From Messrs. W. Brooks & Sons, The Maltings, Mistley, Essex.

27th May, 1884.

Dear Sir,—After a season's use we have nothing to complain of in the Floor you laid for us last year at Colchester. It now looks, and we have no doubt will wear, well.

Yours truly,
W. BROOKS & SONS.

Mr. R. Holliday.

IMPROVED MALT PLOUGHS, SHOVELS, Etc.

SUCROSE.

TRADE MARK.

Since the introduction of this product in 1880, no Brewing Sugar has so successfully borne the test of experience. Its uniform Quality and Strength, and freedom from nitrogenous impurities, attest the extreme care taken in the selection and conversion of the CEREAL employed in its manufacture, further proof being furnished by the high quality obtainable—**nearly 78lbs. per quarter, of 2cwt.** *The most eminent Analysts agree that it is impossible to produce a more satisfactory brewing auxiliary.*

TRADE MARK.

SUCROSE gives a palate fulness not obtained by any other Malt substitute, and may be used in large proportion. A considerable saving is effected when increased quantity of beer is required, without increase of plant and labour.

SUCROSE materially assists the Brewer when the constituents of the brewing liquor are not of a high standard, and renders unnecessary the excessive use of finings and preservative chemicals.

SUCROSE ensures Beers dropping bright rapidly, and never causes deterioration in the yeast.

SUCROSE may be advantageously employed with Malt, even of inferior quality.

SUCROSE produces Beers of excellent keeping quality, and surpassing brilliancy, equally adapted for stock and bottling, and for those of quick draught.

SUCROSE is indispensable to obviate the *mealy* flavour and character induced by raw or gelatinised grain; also the vinous taste and extreme palate sweetness imparted by raw Cane Sugar.

SUCROSE contains the maximum of Grape Sugar and minimum of dextrine and moisture.

In bags containing 1 cwt. in small pieces, and in cases of similar weight for export.

256lbs. are allowed by the Excise to represent a quarter of Malt.

Analyses and further particulars from the Sole Proprietors,

MOUNTAIN, HORSLEYS, & CO.,

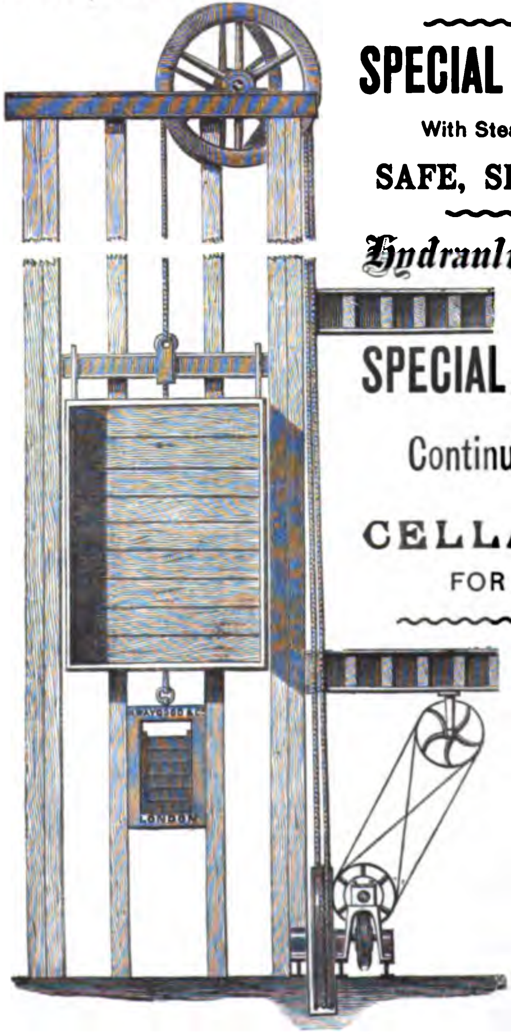
24, SOUTHWARK STREET, LONDON, S.E.

R. WAYGOOD & CO.,

Engineers,

MANUFACTURERS OF

Lifts, Cranes, and Hoisting Machinery.



SPECIAL POWER LIFTS,

With Steam or Gas Engines.

SAFE, SIMPLE, STRONG.

Hydraulic & Hand Lifts.

SPECIAL SACK HOISTS,

AND

Continuous Cask Lifts,

AND

CELLAR LIFTS,

FOR BREWERIES.

SOLE MANUFACTURERS OF

BENNISON'S
PATENT
ROTARY PUMP,

AND

ANDREW'S
PATENT GAS-HEATED
MALT ROASTER.

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LIVERPOOL: 71, LORD STREET. BIRMINGHAM: 70, COLMORE CHAMBERS.

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INVENTORS OF SOLUBLE ESSENCES

For the manufacture of perfect Aerated Waters without rendering them turbid.

ESSENCE LEMON,

(W. J. BUSH AND CO.'S "SPECIALITY" QUALITY).

SOLUBLE ESSENCE LEMON,

SOL. ESS. JAMAICA GINGER, ESSENCE GINGER ALE.

FRENCH CREAM
GUM EXTRACT.

(PROTECTED BY ROYAL LETTERS PATENT),

For producing a permanent head of creamy richness upon all kinds of Syrups, Mineral Waters, Cyders, Beers, Ales, Wines, and all other Liquids or Beverages where a frothy foam or head is required.

ARTILLERY LANE, BISHOPSGATE, LONDON, E.C.

WATER - SUPPLY

IS OF PRIMARY IMPORTANCE TO

BREWERS & MALTSTERS,

AND DEPENDS ENTIRELY UPON GEOLOGICAL CONDITIONS.

H. STOPES & CO. have secured the services of Mr. W. H. Dalton, F.G.S., who, having been on the GOVERNMENT GEOLOGICAL SURVEY for more than 17 years, has thereby become personally acquainted with the nature, position, and water-bearing character of all British rocks. They are, therefore, prepared to advise all questions of water-supply, drainage, minerals, &c.

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ASHTON & GREEN, LIMITED,

Principal Office, where please address all communications,

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Manufacturers of

Slate Stillions, Fermenting Squares, Yeast and Racking Backs, &c.

ASHTON & GREEN use only the best Slate and Materials, and guarantee the quality of their work. References can be given to the leading Brewers.

ESTIMATES SENT FREE ON APPLICATION.

JOSEPH LONG,

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(LATE 20, LITTLE TOWER STREET),
LONDON, E.C.,

Manufacturer of Improved Malt Kiln Thermometers

(REGISTERING AND NON-REGISTERING),

CHRONDROMETERS, MALT MEASURES, MALT CRUSHERS, MALT RECEIVERS, AND SUNDRIES.

ALSO

MANUFACTURER of SACCHAROMETERS, all kinds of BREWING THERMOMETERS, and BREWERS' INSTRUMENTS, as supplied to the Inland Revenue, &c.

Also MICROSCOPES and SUNDRIES for use in Laboratories.

Sikes' Hydrometers,

BOTTLING AND CORKING MACHINES,

For Wine and Spirit Merchants, Bottlers, &c.

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XEREZ DE LA FRONTERA, OPORTO, BORDEAUX, TARRAGONA.

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CASTLE URQUHART LOCH NESS
OLD BLENDED
HIGHLAND WHISKY
PROPRIETOR. HENRY URQUHART. LONDON.

This Whisky is considered one of the finest in the Trade. It is absolutely PURE, and being matured in Sherry Casks, is unrivalled for its great mellowness.

CHAMPAGNES.

PERIGEUX & CO., Propriétaires, EPERNAY.

These Wines rival any of the well-known Brands, they having competitively asserted themselves in a general competition of Champagnes.

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Having constantly special Parcels of various Wines and Spirits on hand, particulars will be sent on application.